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OPERATIONAL ASSESSMENT OF SPACE:

TOWARD EFFICIENCY AND EFFECTIVENESS

by

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Lieutenant Colonel Nathan J. Lindsay Jr. was commissioned through the Officer Training School at Lackland Air Force Base in 1989. Originally entering the Air Force as a test engineer, he has been involved in space operations since 1993. After a space operations assignment at the National Reconnaissance Office, he attended the United States Air Force Weapons School. Upon graduation in 1997, he remained at the school as an instructor. He then completed staff assignments at the Headquarters Fourteenth Air Force as the Chief of Strategy, and Headquarters Air Force Space Command on the Commanders Action Group. Lieutenant Colonel Lindsay has a Bachelor of Science degree in Electrical and Computer Engineering from George Mason University, a Master of Science degree in Systems Management from the College of Notre Dame and a Master of Science degree in Systems Engineering from the Air Force Institute of Technology.

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Preface

While assigned as the Chief of Strategy at the Fourteenth Air Force, I was intrigued with the issue of assessing space at the operational level. During the daily operations briefings, it became clear that we were assessing our own space activities with little or no concept of how these activities were impacting the very operations they were tasked to support. I took on the challenge to develop a better way to assess space operations. My endeavor was cut short, however, by the events of September 11, 2001 as we were thrust into a war we had not planned on fighting. Four years and three assignments later, I had the opportunity to spend some time thinking about and researching the problem in detail. The space assessment problem, however, is not a simple one, and I have not been naïve enough to believe that I could fix it with this thesis. My sole objective has been to highlight the issue and perhaps provide some different ways to understand the assessment problem, with the hope that others will join me in my pursuit of a better way to assess space operations.

The space community has worked diligently to develop better ways to operate space systems in support of theater operations, almost to a fault. In some ways, the space activities may be in excess of what is required or even decipherable. Theater commanders recognize how space has nearly revolutionized their warfighting operations and are not likely to discourage any support the space community offers. Therefore, it's the responsibility of the space community to ensure that what they provide is worth the investment made. This is the point of operational assessment.

I would like to thank Lt Col John Terino for his critiques of my many "good starts" and his encouragement to keep digging deeper. While the thesis is immeasurably improved as a result of his efforts, any shortcomings in the work are solely my own.

Most importantly, however, I wish to thank my family for their love, patience and understanding throughout this endeavor. I could not have completed it without their unrelenting support.

Abstract

Assessing effects is one of the biggest challenges the Air Force faces today. The Air Force has struggled with assessing air operations since they began dropping bombs, and the problem persists today. As problematic as the assessment of combat effects might be for air operations, the assessment of effects from space operations is even more difficult. This thesis uses a theoretical framework to better understand the problem and provide a framework for how the Air Force should address the issue of assessing space operations. By examining experiences from the use of airpower, specifically strategic bombing and close air support (CAS), the thesis will evaluate those lessons in terms fundamental to the issues of assessment. The answers gleaned from this analysis will help inform the Air Force on better methods for assessing space operations in the future.

Operational assessment is the process of relating tactical tasks to operational effects. In the military, tactical tasks are developed with the "theory" that they will enable victory on the battlefield. The scientific method used in this thesis can serve the assessment community well by strengthening theories relating cause and effect and aid in the commander's judgment. This is the very purpose of operational assessment.

The Air Force has historically focused on tactical assessments because it is inherently difficult to assess at the operational level. Operational level space effects are indirect, non-kinetic, indistinguishable from other effects, and often take time to recognize. The theater commander needs both tactical assessments to know that he is doing things right, and operational assessments to know if he is doing the right things. He will probably know if he is not succeeding and want to know why. But what if he is succeeding? Does he assume he is doing the right things? An assumption that it was by design, without any supporting evidence, can set a commander up for future failure.

Recently the Air Force has begun to recognize the importance of operational assessment and has begun to work closely with the theater to understand the desired and actual impact of space activities on theater operations, versus the assumed impact. Continuing in this manner will enable the Air Force to tailor space support to take advantage of the beneficial activities without wasting limited resources on those activities that do not add value.

This thesis only addresses the assessment of force enhancement missions specifically, since they are currently the most predominant military space activity and will likely remain so for the near future. However, the final conclusions and recommendations at the end of this thesis can be readily applied to all space operations, including counterspace. The space assessment problem is difficult and will not be solved in this thesis. Instead, it highlights the fact that operational assessment of space operations is difficult, but it demonstrates it's importance to the development of space power.

Introduction

A tale is told of an old man who was searching the ground under a lamppost one night. A young woman came along and asked if she could help him. The man explained that he had dropped his car keys while attempting to unlock his car. "Where *is* your car?" the woman inquired. "Over there," said the man, pointing across the parking lot. Puzzled, the woman asked, "Then why are you looking here?" The man replied matter-of-factly, "The light is better." Perhaps this story best explains the Air Force's problem with assessing space operations--we have been looking where the light is better, not where the answer is. Admittedly, assessing space is difficult, for a number of reasons, but instead of tackling the problem head on, the Air Force has settled for assessing what is readily apparent, not necessarily what is useful. To put it another way, the Air Force as an institution tends to dub important what is easily assessed, rather than assessing what is really important.[1]

The assessment problem is not unique to space operations, nor is it new for the Air Force. Indeed, the Air Force has struggled with assessing air operations since they began dropping bombs, and the problem persists today. Speaking just a few months after the end of major combat operations for Operation Iraqi Freedom (OIF), Air Force Chief of Staff Gen John Jumper told an audience, "We have to work very hard on things that we continue to do badly—bomb damage assessment. We have to find a way to get accurate and timely bomb damage assessment."[2] More difficult than assessing bomb damage is assessing the effect that the bomb damage had on the operation it supported, referred to today as "effects-based assessment."

[1] Thomas W. Beagle, Jr., "Effects-Based Targeting, Another Empty Promise?" (master's thesis, School of Advanced Airpower Studies, 2001), 96.
[2] Gen John P. Jumper, chief of staff, USAF, address to the Air Force Association National Symposium, Washington D.C., 16 September 2003.

Assessing effects is one of the biggest challenges the Air Force faces today. The 2003 Capabilities Review and Risk Assessment (CRRA) identified effects-based assessment as one of six key capability shortfalls in the Air Force.[3] As problematic as the assessment of combat effects might be for air operations, the assessment of effects from space operations is even more difficult. Part of this difficulty stems from the inherent nature of space operations, and this leaves the Air Force with the daunting task of trying to assess the effects of space operations in a meaningful manner.

The space assessment problem is difficult and will not be solved in this thesis. In this thesis, I will use a theoretical framework to better understand the problem and lessons from the past to help inform the Air Force on better methods for assessing space operations in the future. It begins by defining the key concepts and terms using Air Force doctrine as the foundation in chapter 1. Chapter 2, then, provides some background information on the nature of space operations and space effects. Space operations consist of a broad set of mission areas. To this point in time however, the primary contributions of space have been in the area of force enhancement, often referred to as *space support*. Accordingly, chapter 2 will focus on the force enhancement mission area.

Given a common understanding of the terms and concepts, as well as an appreciation for the nature of space operations, chapter 3 will break down the specific components of operational assessment and the challenges with assessing effects at the operational level. By examining lessons learned from the use of airpower, specifically strategic bombing and close air support (CAS), the chapter will evaluate those lessons in terms fundamental to the issues of assessment. The answers gleaned from this analysis will provide a

[3] "Air Force Materiel Command Set to Correct Capability Shortfalls," *Air Force Print News*, 17 February 2004.

framework for how the Air Force should address the issue of assessing space operations. The implications associated with that framework for the assessment of space effects are presented in chapter 4. That chapter begins by examining how space operations are assessed today and concludes by identifying shortfalls with existing practices. The concluding chapter suggests some actions the Air Force can take to improve space assessment and more effectively utilize space assets.

Before going further, one needs to understand the scope of the thesis in terms of the specific types of space operations discussed here. Space operations consist of a broad set of mission areas that perform force enhancement operations (including communications, navigations, intelligence, surveillance, and reconnaissance [ISR], and warning), as well as counterspace.[4] The unique nature of space operations and space effects discussed in this chapter apply in general to all the space mission areas mentioned above, though not as well to the emerging counterspace mission area. This thesis only addresses the assessment of force enhancement missions specifically, since they are currently the most predominant military space activity and will likely remain so for the near future.[5] An attempt to specifically address a broader range of space operations would distract from the intent of this thesis and, in the end, prove counter-productive. However, the final conclusions and recommendations at the end of this thesis can be readily applied to all space operations, including counterspace.

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[4] These mission areas are some of the primary missions of space. Joint doctrine lists four space mission areas: space control, space force enhancement, space support, and space force application. See Joint Publication (JP) 3-14, *Joint Doctrine for Space Operations*, 9 August 2002. The Air Force, however, does not list these four mission areas for space but instead has a larger list of Air Force functions that includes both air and space operations. See Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, 27 November 2001.

[5] Barry Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2001).

Chapter 1
Assessment and Theory

The deduction of effect from cause is often blocked by some insuperable extrinsic obstacle: the true causes may be quite unknown. Nowhere in life is this so common as in war, where the facts are seldom fully known and the underlying motives even less so.

—Carl von Clausewitz

Before delving into a practical discussion of assessment, an understanding of the theoretical basis for the values and methods associated with assessment is critical to establish the tenets of this analysis. Air Force Operational Tactics, Techniques, and Procedures (AFOTTP) 2-3.2, *Air and Space Operations Center*, defines operational assessment as "the process used at the component level to determine if military operations are producing desired effects leading to achievement of operational objectives and to make recommendations for the future course of component level operations."[6] In short, operational assessment determines the link between a cause and an effect for the purpose of adjusting future activities to better ensure achievement of the desired result. The real interest in understanding the results of past events is for its ability to predict, or control, future events. This has long been one of the aims of science—to predict future events.[7] For this reason, the scientific methodology offers a useful framework for studying operational assessment in the military. It allows military theorists and strategists to observe what happens in war, explain why it happened, and use that information to attempt to predict future events. J.F.C. Fuller, in *The Foundations of the Science of War*, provides one description of this methodology and how hypotheses come to be accepted as laws. Fuller writes, "In brief, the method of science is based on analysis, synthesis, and hypothesis, the one necessarily involving the other. We first observe; next we build a hypothesis on the facts of our observation; then we deduce the consequences of our hypothesis and test these consequences by an analysis of

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[6] Air Force Operational Tactics, Techniques, and Procedures (AFOTTP) 2-3.2, *Air and Space Operations Center* (U), 13 December 2004, 3-58. (Classified) Information extracted is unclassified.
[7] E. Bright Wilson Jr., *An Introduction to Scientific Research* (New York: McGraw-Hill, 1952), 24.

phenomena; lastly we verify our results, and if no exception can be found to them we call them a law."[8] Per Fuller, hypotheses are developed from observation, and then tested. If a hypothesis is validated through sufficient testing, so that it seems unlikely an exception can exist, then it is accepted as law.

Operational assessment is the miltary's process for validating that the activities they are conducting on the battlefield are, in fact, producing the desired effect on the enemy. Since exact conditions between similar cause and effect relationships are impossible to reproduce in combat, and the opportunities to observe them relatively few, operational assessment has been treated as much as an art as a science. By and large, operational assessments include the mechanism, whether implicitly or explicitly. Therefore, an anticipated linkage between a cause and its effect that has not been tested or frequently observed shall be called a hypothesis; and an expected linkage based on a sufficient level of testing or observation shall be generally be referred to as a theory, or on occasion, simply a law.

There has long been much debate in the scientific community regarding methods for validating theories. One common method is through inductive reasoning, or *induction*.[9] First established in the scientific community by Sir Francis Bacon, and later adopted by Sir Isaac Newton, this method gained popularity among philosophers of science in the 1920s, including Ernst Mach and the Vienna Circle.[10] Using inductive reasoning, one derives generalities from a series of specific observations. For example, one might repeatedly observe swans and note that every swan *seen* is white. Using inductive reasoning, one may arrive at the conclusion that *all* swans are white. As long as all of the evidence is favorable, a theory is validated. Similarly, when conducting experiments, one might use test results to support a theory. The possibility exists that those conducting the experiments might have a vested interest in validating their own theories, and so tended to test for the results they want.[11] In other words, they were looking for white swans. As will be shown later, space activities are often assessed (by

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[8] Colonel J.F.C. Fuller, D.S.O., *The Foundations of the Science of War* (London: Hutchinson & Co., 1926), 45-46.
[9] Wilson, 27.
[10] Ernst Mach, *The Science of Mechanics*, translated by Thomas J. McCormack. (LaSalle, IL: Open Court, 1974: Reprint of sixth edition, 1893).
[11] Anthony M. Alioto, *A History of Western Science* (Englewood Cliffs, N. J.: Prentice Hall, 1993), 164.

the space community) using inductive methods to arrive at favorable conclusions about the utility of space operations.

In the 1930s, Karl Popper argued that scientists should be looking for black swans. He believed scientist should test theories with the intent of trying to disprove them.[12] He discarded induction based on the fact that, unless there are only a finite number of cases to test, inductivism can never prove anything. To counter it, he introduced the concept of *falsification* as the proper method.[13] Falsification contends that theories should be tested not with the intent to validate them, but with the intent to invalidate them. As Albert Einstein once said, "No amount of experimentation can ever prove me right; a single experiment can prove me wrong."[14] Good theories may never be proved right, but are strengthened by the fact that they stand the test of time against critics and experiments. Military commanders should use operational assessments to validate theories linking tasks and desired effects. Furthermore, the assessment community should seek oportunities to *disprove* these theories.

For our purposes, the scientific method serves as a very useful framework for an analysis of assessment. Assessment is conducted to determine the link between events and outcomes, or between causes and effects. Assessment begins with observations, followed by hypotheses or theories (depending on the level of supporting evidence) that link a cause with an effect. Ideally, attempts are then made to validate these theories through observation, experimentation, and experience. Though never actually proven, these links between cause and effect are treated as truths until proven otherwise. By definition, all theories have some gap in evidence, leaving the definitive linkage between a cause and its effect up to one's best judgment. The smaller the gap, the better the theory, and the better the ability to use the theory to predict effects of a given cause. It is judgments such as these that make war more an art than science.

While many war theorists dwell on the *art* of war, the *science* of war has certainly not been overlooked by the major military theorists. J.F.C. Fuller, for example, entitled his theory of war, *The Foundations of the Science of War*. Carl von Clausewitz used a very scientific framework to explain his own "art of war." Clausewitz believed that

[12] Alioto, 164.
[13] Karl Popper, *The Logic of Scientific Discovery* (London: Hutchinson, 1959).
[14] Quoted from http://www.brainyquote.com/quotes/quotes/a/alberteins100017.html.

there was great value in theorizing about war, but understands that war is fought by practitioners, not theorists, and eventually theories must give way to reason or judgment on the part of the military commander. In *On War*, Clausewitz writes, "Theory exists so that one need not start afresh each time sorting out the material and plowing through it, but will find it ready to hand and in good order. It is meant to educate the mind of the future commander, or, more accurately, to guide him in his self-education, not to accompany him to the battlefield."[15]

Clausewitz recognized that theories cannot be completely proven due to inherent evidence gaps and his analysis provides an excellent discussion of the use of theory to explain the link between cause and effect. According to Clausewitz, the evidence gap in a theory can be reduced through three activities associated with a critical analysis. The first is "the discovery and interpretation of equivocal facts." This is essentially analyzing historical data and observing events.[16] The second activity is "the tracing of effects back to their causes." This, he writes, "is critical analysis proper. It is essential for theory."[17] The third and final activity is "the investigation and evaluation of means employed. This is criticism proper, involving praise and censure."[18] Clearly, the third step, where one determines if the cause created the effect, relies heavily on the second step, conducting a critical analysis to trace the effect back to the cause.

It is only through this analysis that one can definitively link a cause and an effect. Clausewitz describes what happens when there is no critical analysis or when such analysis fails to produce sufficient evidence.

> …the disparity between cause and effect may be such that the critic is not justified in considering the effects as inevitable results of known causes. This is bound to produce gaps—historical results that yield no useful lesson. All a theory demands is that investigation should be resolutely carried out till such a gap is reached. At that point, judgment has to be suspended. Serious trouble arises only when known facts are forcibly stretched to explain effects.[19]

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[15] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1976), 141.
[16] Ibid., 156.
[17] Ibid.
[18] Ibid.
[19] Ibid.

To summarize Clausewitz, critical analysis reduces the gap between the cause and the effect, thus making the theory stronger. He cautions, however, that in the end there will still exist some form of gap and judgment is required to put the theory into practice.

One of the premises of this thesis is that military planning is conducted using theories. Operational plans are devised with underlying theories about what the effects of given causes will be; such as how the enemy will react to a particular action, or how a friendly activity will benefit another friendly activity. At the highest level, the operational plan is the cause, and the campaign objective is the desired effect. In reality, military planning at all levels relies very heavily on theories, not laws. These theories run the gamut from the strategic level, such as theories of war, to the tactical level, where tactics are developed and employed based on theories that link causes and effects. In between, at the operational level of war, we use theories to, among other things, link outcomes of battles and engagements to success in higher level campaigns.

If the difference between a theory and a law is the evidence that supports it, then military operations should ideally be based on laws that link causes and effects, and not on mere hypotheses. While in reality this may not be possible, it is imperative to "close the gap" in those theoris as much as possible, and that is the purpose of assessment. The better the assessment, the better the validation of theories and military plans based on those theories. We must be careful, as Clausewitz heeds, not to impose our own judgments in order to link a cause to an effect. However, he also warns against suspending judgment too soon. Clausewitz says "One must not stop half-way, as is done so often, at some arbitrary assumption or hypothesis."[20] Applying Clausewitz's warning to assessing military operations, we must conduct a thorough analysis, or assessment, to link causes and effects, not simply assume that the link is there. Yet, we must avoid closing the gap by simply stretching the facts. There is a tendency to do this throughout military operations, but especially in space operations, where the space community is trying hard, sometimes too hard, to make operations relavent.

Before leaving this topic, it is worth reiterating the importance of assessment in military operations, and particularly in space operations. Assessment is the means to

[20] Ibid.

validate theories of how to employ forces to defeat an adversary. Assessments should not be based on arbitrary assumptions, or stretched truths, but on critical analysis. Faulty assumptions or analyses can incorrectly link causes to the wrong effects, or link effects to the wrong causes. Clearly in war, such mistakes can lead to loss of lives and political capital, and military materiel, if not to outright defeat.

Terminology and Doctrine

Engaging in a useful analysis on the topic necessitates presenting a common understanding of the terms and concepts employed. Using Air Force doctrine as the primary source, this section defines the terms *effects* and *assessment* at different levels of warfare, and the common tools used to assess military performance, *measures and indicators*. The section then reviews existing doctrine to understand how both the Air Force and the joint community describe the operational assessment process.

Effects

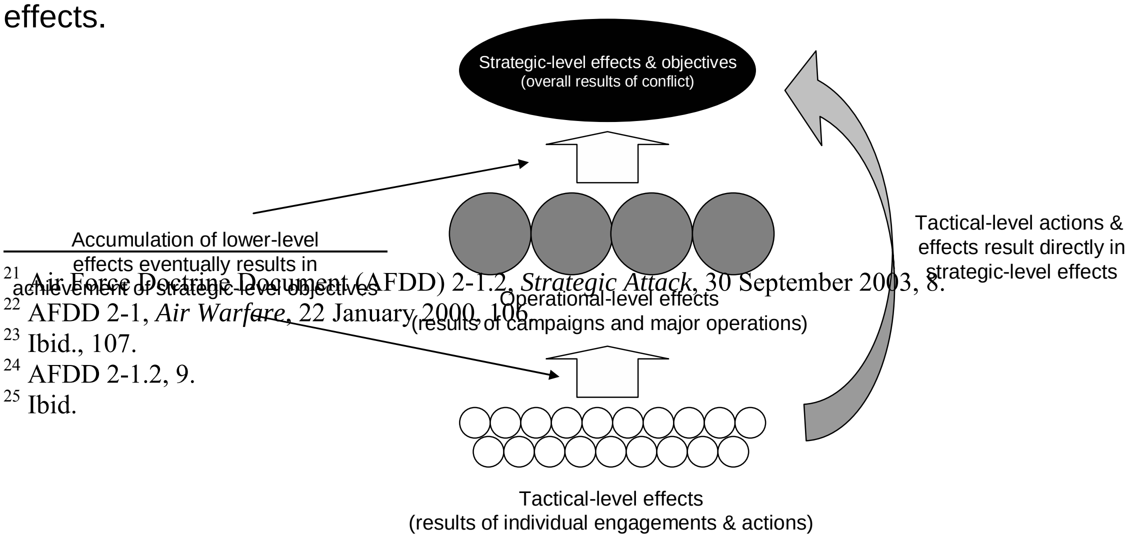
The term "effect" is often used in a variety of manners, and usually not defined or put into the proper context. There are many types and levels of effects and it is important that any discussion of effects clearly explain the type of effect that is under review. Air Force doctrine offers a good starting point for developing a common understanding of effects. Perhaps the most robust discussion of "effects" is found in Air Force Doctrine Document (AFDD) 2-1.2, *Strategic Attack*, which defines them as:

> …the full range of outcomes, events, or consequences that result from a particular action or set of actions. Specific actions produce specific ("direct") effects, those effects may produce other ("indirect") effects, and this chain of cause and effect creates a mechanism through which objectives are achieved. An objective is an ultimate desired outcome of a set of effects. Objectives at one level may be seen as effects at another, higher level. Effects, however, comprise all of the results of a set of

actions, whether desired or undesired, ultimate or intermediate, expected or unexpected.[21]

Direct effects are the "result of actions with no intervening effect or mechanism between act and outcome. Direct effects are usually immediate and easily recognizable."[22] *Indirect* effects are results "created through an intermediate effect or mechanism to produce the final outcome, which may be physical or psychological in nature. Indirect effects tend to be delayed and may be difficult to recognize."[23]

In addition to being direct or indirect, effects occur at every level of war: tactical, operational, and strategic.[24] Since the topic of this thesis is assessment at the operational level, it will naturally focus on effects from the tactical level up to the operational level. Tactical level effects are the results of individual engagements or actions.[25] They are most often direct effects experienced by an individual or a single system. Operational effects are the result of campaigns or major operations. Tactical level effects often feed into operational and strategic effects. For example, a tactical engagement can have an effect on an operation, however, it is usually one of many tactical operations. It is the aggregate of all those tactical operations that produces the result of the overall operation. Therefore, tactical effects usually produce indirect operational effects, in that they are usually not immediately or easily recognizable. In the same manner, operational effects feed into strategic effects. The scope of this paper, however, is operational level effects, and the tactical level effects that help produce them. Figure 1 depicts the relationship between the different levels of objectives and effects.



[21] Air Force Doctrine Document (AFDD) 2-1.2, *Strategic Attack*, 30 September 2003, 8.
[22] AFDD 2-1, *Air Warfare*, 22 January 2000, 106.
[23] Ibid., 107.
[24] AFDD 2-1.2, 9.
[25] Ibid.

Figure 1--Relationship between Strategic, Operational, and Tactical Effects
Source: Modified from AFDD 2-1.2, 9.

In addition to the different levels of effects, there are other useful ways to categorize effects. Effects may also be *intended* or *collateral*. "Collateral effects are unintended outcomes, which may have a positive or negative impact on friendly operations."[26] Finally, effects may be *physical*, *psychological, functional*, or *systemic*. Physical effects are kinetic effects and usually direct effects. Psychological effects, on the other hand, "influence the emotions, motivations, or reasoning of individuals, groups, or polities, and are usually conveyed by changes in behavior."[27] A functional effect addresses the extent to which the functionality of the target has been degraded or affected.[28] Finally, systemic effects "describe how the behavior of a system is changed by action against it."[29] While physical effects are almost always direct effects, psychological, functional, and systemic effects are by nature almost always indirect."[30] A final useful category is *cumulative* effects.[31] These are the aggregate of many effects (direct and indirect) on a target system and represent the cumulative result. Cumulative effects are easily observed, yet very difficult to predict. With an understanding of the various types of effects, our attention now turns to assessments performed at the different levels of warfare.

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[26] Ibid.
[27] Ibid.
[28] Definitions. Air Force Effects-Based Operations and Assessment Working Group, 22 February 2005.
[29] AFDD 2-1.2, 9.
[30] Ibid.
[31] Ibid.

Assessment

Assessments are performed at all levels of warfare: tactical, operational, and strategic. As with the discussion of effects, however, this paper will address assessment at the tactical and operational level. The most common form of assessment is tactical assessment. Bomb damage assessment (BDA) is an example of a tactical assessments. Tactical assessments determine if an engagement or operation successfully accomplished the tactical or mission objective. At the next level up, "Operational assessment determines whether or not force employment is properly supporting overall strategy by meeting operational objectives."[32] In a sense, tactical level assessments simply answer the question "What did we do?" For a Joint Force Commander (JFC), the operational assessment that answers the more pertinent question, "How are we doing?" Operational assessment, then, is the focus of this thesis.

Operational Assessment

As previously stated, *AFOTTP 2-3.2* defines operational assessment as "the process used at the component level to determine if military operations are producing desired effects leading to achievement of operational objectives and to make recommendations for the future course of component level operations."[33] According to the document, operational assessment "stems from the historic concerns of commanders to ascertain how well they are doing and to identify how to do things better, quicker, or more effectively."[34] This doctrine clearly places the responsibility of operational assessment with the component commander. The reason for this is that operational objectives are assigned to the component commander and it is his job to assess those objectives. It is important to realize, however, that operational assessment, just like operational objectives, are not necessarily confined within one component. While one component commander is assigned an operational objective, there may be multiple

[32] AFDD 2-1, 107.
[33] AFOTTP 2-3.2, 3-58.
[34] Ibid., 3-79.

tactical objectives supporting that operational objective. Those supporting tactical objectives may be assigned to other component commanders. The same goes for assessment. It is the component commander's responsibility to do the operational assessment for his operational objectives, however, tactical assessments from other components are often required to do the assessment. The operational assessment process will be discussed in further detail, but first the tools used in this process need to be defined.

Measures and Indicators

The tools used to gauge the progress toward an objective are measures of effectiveness (MoE) and success indicators (SI). Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, defines MoEs as "tools used to measure results achieved in the overall mission and execution of assigned tasks."[35] Typically, MoEs are quantitative in nature and used at the tactical level where effects are measurable. However, at the operational level, where effects are usually not measurable, it is common to use success indicators to gauge progress. Success indicators are subjective measures of objectives used when quantitative measures are not available.[36] According to JP 3-30, *Command and Control for Joint Air Operations*, "Success indicators support operational objectives, providing broad, qualitative guidance for operational assessment."[37] With an understanding of the measures and indicators, we can now look more closely at the operational assessment process.

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[35] Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 12 April 2001, 328.
[36] AFOTTP 2-1.1, *Air and Space Strategy*, 9 August 2002, 31.
[37] JP 3-30, *Command and Control for Joint Air Operations*, 5 June 2003, III-10.

Operational Assessment Process

AFOTTP 2-3.2, *Air and Space Operations Center*, provides a slightly more comprehensive description of the operational assessment process and brings up some important points.

> Operational Assessment as a process starts with careful development of measures and data mapping (strategy-to-task) and then follows in reverse order (action-to-effect) to link results back to their objectives. It culminates with detemining that the desired effects of a particular objective are met and then recommends changes to strategy (using predictive analysis) to meet intended goals. This process does not work effectively without both the "operational art" (subjective) and the "tactical measurements" (objective) to support findings. Objective data does not determine whether desired effects are produced, but gives weight to subjective conclusions.[38]

AFOTTP 2-3.2 points out that an operational assessment requires both operational art and tactical measurements. The purpose is to use what was learned in a predictive manner to change ones strategy as necessary to produce desired effects. The last sentence bears repeating as it sums up the whole concept of operational assessment: *Objective data does not determine whether desired effects are produced, but gives weight to subjective conclusions*.[39] Operational assessments are subjective and usually qualitative in nature, but are based on quantitative MoEs at the tactical level. Although the overall operational assessment process uses a scientific methodology, it is based on theories of causal relationships and hence, is not purely objective. In the end, subjectivity plays an important role in assessment.

Strategy-to-Task Methodology: The Critical Analysis

Before discussing the some historical problems associated with operational assessment, it is necessary to understand the strategy-to-task methodology and how it works. A strategy-to-task methodology begins with the highest-level objectives from which all lower level objectives flow. In the military, this generally begins with the Joint Force Commander's (JFC) intent. The commander's intent should clearly spell out the overall objectives of the campaign to include the purpose of the campaign and the desired

[38] AFOTTP 2-3.2, 3-80.
[39] Ibid.

military end state when the conflict has ended. From this intent, subordinate commanders can develop operational objectives. In theory, when subordinate commanders have met all the operational objectives, they will have achieved the JFC's desired end state and met his intent. In turn, operational objectives are supported by lower level tactical objectives. If the tactical objectives are correct, then the aggregate result of achieving all the tactical objectives will result in the accomplishment of the operational objectives. Taking the concept one step further, tactical objectives are supported by tactical tasks. These are the actual activities that must be performed in order to accomplish the tactical objective. Once again, if the tactical tasks are correctly identified, then the collective result of achieving all the supporting tactical tasks will result in the accomplishment of the tactical objective. This discussion of operational assessment will stay below the commander's intent level and will deal only with operational objectives and the tactical level objectives and tasks that support them.

Various objectives and tasks are tracked to determine progress. This is accomplished using measures and indicators as described in the first chapter. Ideally, everything would be quantitative and measurable. This is more common at the tactical level with direct effects, and success is usually tracked using quantifiable measures of effectiveness (MoE). Sometimes, however, there is no measurable quantity associated with an objective or task, so measures of effectiveness are not possible. In this case, success is tracked using success indicators (SI) where there is a recognizable (though not measurable) indicator that can be used to determine that an objective has been met.[40] A baseball analogy is a good way to explain the strategy-to-task methodology.

In a baseball game, the operational objective is to win the game. In preparation for the game, a manager develops a game plan. The manager may determine that he can win the game with good pitching, good hitting, and good fielding. Therefore, he may develop tactical objectives for each of these. For example, the manager may decide that he wants his pitcher to keep opposing hitters from reaching base. This is a tactical objective. In order to quantify success, the manager determines that his pitcher cannot allow more than seven hits and three walks. These numbers become his measures of effectiveness for that

[40] AFOTTP 2-1.1, 31.

tactical objective and they are based on his knowledge of his team's pitching and the opposing team's hitting abilities. He believes that if they can do this, they will have met the tactical objective of keeping the opposing hitters from reaching base. In addition, the manager defines another objective as getting his own hitters on base. This tactical objective could be quantified with an MoE that specifies getting at least ten hits off the opposing pitchers. Furthermore, he may specify that they need at least five extra base hits. This adds two more tactical tasks and MoE's. Finally, he determines that good fielding can only be accomplished if they do not have any errors in the game. This becomes a final tactical task and MoE. For clarity, the objectives and tasks are presented below in a common strategy-to-task format employed by the military, complete with measures of effectiveness:

Operational Objective: Win the baseball game

- Tactical Objective 1: Effective pitching
  - Tactical Task 1.1: Allow 7 or fewer hits (MoE inherent)
  - Tactical Task 1.2: Allow 3 or fewer walks (MoE inherent)
- Tactical Objective 2: Get to opponent's starting pitcher early
  - Tactical Task 2.1: Collect at least 10 base hits (MoE inherent)
  - Tactical Task 2.2: Collect at least 5 extra-base hits (MoE inherent)
- Tactical Objective 3: Solid fielding
  - Tactical Task 3.1: Commit no defensive errors (MoE inherent)

The idea is that by accomplishing all the tactical tasks, they meet their tactical objectives, and by meeting the tactical objectives, they will accomplish the operational objectives of winning the game. This is the strategy-to-task methodology.

In the military, the strategy-to-task methodology provides a theory for winning a campaign and it is accomplished by conducting what Clausewitz calls the critical analysis, the second step of the critical approach presented earlier in this chapter. According to Clausewitz, critical analysis is "the tracing of effects back to their

causes."[41] In this context, it is the process by which one starts with the operational objective, and works downward to arrive at the tactical tasks necessary to achieve the operational objective. A military example puts the concept in proper context. AFOTTP 2-1.1 offers a potential counterair operational objective as, "Air superiority throughout the Joint Area of Operations (JOA)." In this example, air superiority in the JOA is the desired effect and the objective at the operational level. A supporting tactical objective is listed as, "Enemy fixed- and rotary-wing attack capability neutralized." This is the desired tactical effect. A tactical task listed against this tactical objective is to, "Defend friendly assets from attack by fixed- and rotary-wing aircraft using Surface-to-Air Missiles (SAM) & Anti Aircraft Artillery (AAA)."[42] The theory, then, is that defending friendly assets from attack by fixed- and rotary-wing aircraft using SAM & AAA, is necessary to achieve air superiority throughout the JOA. Furthermore, the theory follows, if all the tactical tasks are accomplished and all the tactical objectives met, the operational objectives will be achieved as well.

Military planners, however, often interpret the strategy-to-task methodology as law rather than as theory. Unfortunately, while the strategy-to-task methodology works great in theory, it does not work as well in practice. The fallacy of the concept should be apparent. Consider again, the baseball analogy. The operational objective was to win the game. However, there are multiple scenarios where the team could have accomplished all the tactical objectives according to the MoEs (give up fewer than seven hits, collect ten hits of their own, get five extra base hits, and commit no errors), and still lost the game. To put it another way, they could have executed the game plan perfectly, yet lost because the game plan itself was flawed. Conversely, the team could conceivably have failed to meet several tactical objectives, yet still won the game. As Clausewitz warns, "A critic should never use the results of theory as laws and standards, but only—as the soldier does—as *aids to judgment*" (emphasis in original).[43] In other words, the methodology should only serve to assist in developing the initial tasks. By nature, the theory will have gaps in the links between the causes and effects and we must not stretch

[41] Clausewitz, 156.
[42] AFOTTP 2-1.1, 56.
[43] Clausewitz, 158.

the facts to assume effects.[44] Clausewitz uses the term "law" not as it is used in this thesis, but as something more, as a proven fact. He is warning that no matter how well the theory has been tested and validated, practioners must never think as if the theory has been proven. In spite of Clausewitz's remark about the soldier, the military is as guilty as anyone at treating the strategy-to-task *theory* as a proven fact.

Assessing the Linkages: The Critical Inquiry

Recognizing that the linkages between the tactical tasks and the operational objectives are purely theoretical, the third step of Clausewitz's critical approach is the "investigation and evaluation of the means employed." Known as the *critical inquiry*, this process "poses the question as to what are the peculiar effects of the means employed, and whether these effects conform to the intention with which they were used."[45] Compare this to our definition of operational assessment as being "the process used at the component level to determine if military operations are producing desired effects leading to achievement of operational objectives."[46] From these definitions, it is evident that just as Clausewitz's *critical analysis* is the process of linking tactical tasks to operational objectives; his *critical inquiry* is the process of determining if those tactical tasks were appropriate given the desired objective. Together, the critical analysis and the critical inquiry make up what we call *operational assessment*.

As the baseball analogy shows, success requires more than accomplishing all the stated tactical tasks or meeting all the identified tactical objectives. Achieving the operational objective requires doing the right tactical tasks. As the catch phrase goes, it is not just about doing things right, it's about doing the right things. The strategy-to-task methodology is not a checklist for success; therefore, one must not assume that achievement of the operational objective implies that the right tactical tasks have been executed. Similarly, one can't assume that accomplishment all the measurable tactical

[44] Ibid, 157.
[45] Ibid.
[46] AFOTTP 2-3.2, 3-58.

objectives caused the achievement of the operational objective. Clausewitz uses the example of battlefield tactics. It is normally accepted that the cavalry is posted behind the infantry, he says, yet it would be "foolish" to assume any other formation is wrong, simply because it is different. Similarly, he adds, "if theory lays it down that an attack with divided forces reduces the probability of success, it would be equally unreasonable, without further analysis, to attribute failure to the separation of forces, whenever both occur together; or when an attack with divided forces is successful to conclude that the original theoretical assertion was incorrect. The inquiring nature of criticism can permit neither."[47]

It is even more tempting, when results appear to validate the theory, to dismiss further analysis as unnecessary. For example, if the baseball manager won the game and successfully achieved all his tactical objectives along the way, he may assume his game plan was correct and fail to investigate further. In reality, the game plan may have been terrible, yet the team may have won for other less obvious reasons. As Clausewitz puts it, "the disparity between cause and effect may be such that the critic is not justified in considering the effects as inevitable results of known causes."[48] Such assumptions will most likely lead to future operational failures. Herein lies the value, and the challenge, of operational assessment.

[47] Clausewitz, 158.
[48] Clausewitz, 156.

The Importance of Assessing Space

The argument for why it is important to do operational assessments should be clear. However, one may not see yet why assessing space itself is so important. After all, currently and for the foreseeable future, space operations are limited to force enhancement activities. Throughout each conflict since Operation Desert Storm, space has gradually evolved from an entity employed in an ad hoc fashion to a well integrated component that has transformed military operations on land, sea, and in the air. This significant increase in the use of and reliance on space has taken place without the benefit of any form of theory on how to best employ space power. Since it is still early in the development of space power, and space is far from realizing its full potential, it is important to begin developing theories to guide the further development and employment of space assets in future conflicts.[49] Certainly there is still much to learn about space operations and early theories may not endure, yet the mere existence of such theories will provoke thought and stir debate on the issues which will benefit space power in the manner that early theories on air power were instrumental in developing air doctrine.

John Slessor opined in 1939 that air was best employed in support of surface forces. While many early air power theorist advocated the independent employment of air power to achieve its own objectives, Slessor argued, "Air superiority is only a means to an end, and unless it is kept in its proper place as such, is liable to lead to waste of effort and dispersion of force."[50] One can easily see the parallel with space operations today. The space weaponization issue has recently moved to the forefront of discussion once more and space superiority is still a top priority for the Air Force.[51] Is weaponizing space the best application of space power or should the Air Force concentrate on force enhancement? How heavily do air, land, and sea forces actually rely on space today? How vulnerable are our force enhancement capabilites to enemy interference? Are there

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[49] One such theory has already been put forward by Everett C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (Portland, OR: Frank Cass, 2002).

[50] John Slessor, *Air Power and Armies* (London: Oxford University Press, 1936), vii. For other theories that supported independent air operations see Giulio Douhet, *The Command of the Air*, trans. Dino Ferrari (1942; new imprint, Washington D.C.: Office of Air Force History, 1983).

[51] Walter Pincus, "Plans by U.S. to Dominate Space Raising Concerns: Arms Experts Worried at Pentagon Push for Superiority," *Washington Post*, 29 March, 2005, A02.

future force enhancement capabilities that the Air Force should be trying to tap? Or, is it time to begin the progression toward weaponization? These are important questions that deserve debate. Operational assessments of space operations in conflicts today will go a long way toward informing these discussions.

This chapter has defined the terms and concepts used throughout the remainder of the analysis. Operational assessment provides the critical information that the theater commander needs to know how his campaign is performing. To understand how the assessment tools and process relate to space requires an understanding of space operations. The next chapter shifts gears to provide a basic understanding of space operations. The unique nature of space operations and their effects have a significant impact on our ability to assess them.

Chapter 2

Understanding Space Operations

Space is different. It requires a different culture, different operating principles and a unique respect for what it brings to the fight.

—John P. Jumper

The differences between air and space are more than simply the altitude at which the two mediums operate. The physics of the air and space mediums create differences that drive the very nature of how we operate in each of them. Additionally, the effects produced from space are, for now, non-kinetic in nature--a stark contrast from the predominantly physical nature of air power. Finally, there are cultural differences between air and space that cannot be cast aside. This chapter will address each of these differences in greater detail for the purpose of providing the reader with a sufficient understanding of the uniqueness of space. It is only within the context of that understanding that one can fully comprehend the problem of assessing space.

The "Utility" of Space

The number of bombs dropped, the number of combat missions, the number of hours flown, and other statistical tallies usually comprise what passes for analysis of air power. A take-off and a landing clearly demarcate an air mission or "sortie," assessments are usually performed for a given mission or sortie. On the other hand, space power is more omnipresent. Spacecraft remain on orbit, continuously performing their mission. As a result, space operations are generally not assessed on an individual mission basis as are most air operations. A good example of this is the Global Positioning System (GPS) service, a constellation of 27 satellites providing global navigation and timing worldwide, 24 hours a day, 365 days a year. As a free service, available to anyone with a GPS receiver, it is often taken for granted. Few realize the around-the-clock operations required for maintaining a healthy constellation of satellites and keeping each satellite functional with current position and timing updates. Yet, everyone expects the service to always be there for them when they need it, 24 hours a day. Gen Lance Lord, commander of Air Force Space Command, the organization responsible for launching and maintaining the GPS constellation, likes to refer to GPS as "the world's greatest free utility."[52] However, by thinking of space products as free utilities, there is a tendency to see them as unlimited resources. In fact, many space products are limited resources and require judicious apportionment to theater commanders for specific purposes; prominent among these products are communications bandwidth and intelligence products. Considering basic GPS service as free and unlimited may blind many to the realization that certain theater-tailored GPS services are not unlimited and occur at the expense of other theaters or perhaps the system as a whole. These types of space operations should be tasked against specific objectives and accurately assessed to ensure their appropriate and effective use, just as is done with air operations.

[52] Gen Lance W. Lord, statement before the Subcommittee on Strategic Forces of the Senate Armed Services Committee, U.S. Senate, 16 March 2005.

The Nature of Space Operations and Space Effects

Space operations are indeed unique when compared to air, land, or sea operations, in several respects. Most space operations support friendly combat forces and are not directed against enemy forces. Additionally, although space operations are global in nature, they also may have theater missions.[53] Finally, space operations can support individual theater, multiple theater, or national objectives, and the command and control structure varies between the three.[54] Air, land, or sea operations may exhibit each of these characteristics, but when put together they make space operations truly different from the other mediums. These characteristics will each be addressed individually.

First of all, most space operations are conducted in support of friendly combat forces, not against enemy forces. This is in contrast to most air missions that lend themselves to assessment. For example, close air support (CAS), offensive counter air (OCA), and suppression of enemy air defense (SEAD) are air missions that support other friendly forces. However, the enemy will certainly experience the effects of those CAS, OCA, or SEAD missions directly. In this sense, space operations are similar to airlift, air refueling, or airborne ISR operations. Airlift, refueling, and ISR operations require different assessment tools than strike operations. The operational effects of space then must be assessed not by their impact against the enemy but by their support to friendly forces.

Secondly, space operations are global in nature but can support individual theater, multiple theater, or national objectives.[55] Global and theater effects from space are not necessarily mutually exclusive, but they can, and often do, compete with one another. Some constellations of satellites can produce generic effects to all points on the earth simultaneously, but specific effects for a specific theater come at the expense of global effects, or specific effects in a different theater. This is characteristic of airlift or strategic bomber operations, which have global reach capabilities. However, while different theaters may compete for airlift or bomber assets, those platforms do not support multiple

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[53] AFDD 2-2, *Space Operations*, 27 November 2001, 26.
[3] Ibid.
[55] AFDD 2-2, pg 26

theaters simultaneously the way space does. Furthermore, a space asset may be supporting multiple objectives in one theater in addition to other objectives in other theaters. Therefore, space effects should not be assessed against the objectives of a single commander but rather should be assessed against each supported commander's separate objectives.

Finally, the direct effects of space operations are, by nature, non-kinetic and often transparent. Many times space consumers are not even aware that they are using space. For example, a team of researchers surveying the impact of space operations during the first Gulf War discovered, "In many cases, the users were not aware of space capabilities. For example, how communications satellites influenced combat operations was not documented because what was said over the phone in hundreds of thousands of phone conversations was not recorded and not documented. Many users, moreover, were not aware that they were talking via satellite."[56] Although non-kinetic effects can be just as effective as kinetic effects, they are much less readily apparent and much more difficult to assess.

The direct space effects are also typically systemic effects. As discussed in chapter 1, systemic effects change the behavior, not the physical nature, of the targeted system (keeping in mind that the targeted system of space effects is often a friendly system it is supporting). Doctrine, however, describes systemic effects as "by nature almost always indirect."[57] This may be true of operations in other mediums, where the direct effects of operations are often physical, kinetic effects. In space, however, the direct effects are systemic and as such are more difficult to assess. In this respect, space operations are similar to information operations.

Yet, what makes space different from information operations, and inherently more difficult to assess, is the fact that operational effects of information operations are usually direct effects since they target enemy forces and enemy behavior directly. The operational effects of space operations, on the other hand, are usually second or third order indirect effects. These effects are especially difficult to detect and, if detected, even more difficult to distinguish from effects caused by other sources.

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[56] Maj Teresa R. Clark et al., *Gulf War Air Power Survey (GWAPS)*, vol. 4, part 2, "Space Operations" (Washington D.C.: Government Printing Office, 1993), vii.
[57] AFDD 2-1.2, 9.

The Culture of Space

The space culture in the military has historically been very different from flying culture.[58] Ben Lambeth articulated the problem well, stating that in spite of efforts to integrate air and space:

> …air and space remained separate domains of activity within the Air Force, each populated by individuals with widely dissimilar vocabularies and mindsets.
>
> There even developed what must be acknowledged as something of a mutual distrust between the two communities as distinctions began to form between the "real men" who wore wings and flew jets and those in the emerging missile and space world, who all too often were shrugged off by their aviator brethren as "techies,"…"space cadets," or—worse yet—"space geeks." For their part, the proud but beset-upon professionals in the fledgling space community took due note of their rejection by the operators and, in natural fashion, circled the wagons and forged a self-protective sense of separate identity.[59]

Fueled by the significant contributions of space in Operation Desert Storm and the advent of GPS, the military space culture began to change. Space zealots began to sell (and often oversell) the capabilities that space brought to the fight. Air Force Chief of Staff Gen Merrill McPeak, for example, was quick to tout Desert Storm as "the first space war."[60] Others, however, questioned whether the purely support functions of space warranted such accolades.[61] While the space community beat its collective chest over its successes in Desert Storm, others pointed out some of the inherent limitations and outright failures of the space community during the war. The space community, while

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[58] J. Kevin McLaughlin, *Military Space Culture* (Washington D.C.: The Commission to Assess United States National Security Space Management and Organization, January 2001).
[59] Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, N.Y.: Cornell University Press, 2000), 234.
[60] Gen Merrill A. Mc Peak, chief of staff, US Air Force, briefing to the National War College, Fort Leslie J. McNair, Washington D.C., 6 March 1991.
[61] Lambeth, 238.

leaning forward to meet the needs of the warfighter, has often been guilty of overselling existing capabilities and understating shortfalls.

John Olsen recently made the following observation regarding air power after Desert Storm. Suggesting that airmen constantly have to defend their record, he says that others find it,

> …inevitably easier to deal with what air power did not accomplish…Part of the explanation might be that air power visionaries, since the days of Douhet, Mitchell, and de Seversky, have always claimed more than they could justify…Another aspect might be the 'nature of the beast'. While armies occupy territory air power does not, and therefore one lacks the traditional reference of advance and retreat, which often indicates success and failure.[62]

Olsen identified two issues that might equally impact the Air Force's ability to assess space operations. First, there is a tendency among the space community to over-inflate assessments of their operations, partly to counter the critiques and partly to claim their share of the victory. Second, if air operations have proven to be more difficult to assess than land or sea operations, one can easily argue that space operations are even more difficult to assess than air. As a result, the space community tends to err on the side of success. Most of the differences between air and space described above are the same issues that set air operations apart from land and sea operations.

At this point, however, it is useful to look at an actual example of a space system and the effects it produces. GPS offers a good illustration of the uniqueness of space operations and space effects. The next section provides a brief general description of the GPS system and a tactic that provides tailored GPS support to a specific theater.

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[62] John A. Olsen, *Strategic Air Power in Desert Storm* (Portland, OR: Frank Cass, 2003), 286.

The GPS System and Effects

The GPS system is a force enhancement capability that provides precision timing and position data for friendly military forces. The intent of this thesis is not to provide an in-depth description of the GPS system; such information is readily available in other documents.[63] Rather, the intent is to use GPS as a pertinent operational example to help illustrate and support the premises of this work. To do that, it is necessary to provide a minimal amount of background information on GPS that is germane to the discussion.

The GPS system is currently the only space constellation that produces truly global effects in the sense that they are generic effects to all points of the earth simultaneously. Most systems that claim to be global in actuality do not have coverage of the polar regions of the earth. GPS, on the other hand, is in a medium earth orbit (MEO) that covers all regions of the earth, including the poles. A MEO constellation of 27 satellites, dispersed among six circular orbital planes of 4-6 satellites, comprise the constellation. All six planes have the same inclination and are evenly spaced 60 degrees from each other around the globe, as depicted in figure 2. The constellation enables the GPS system to provide equal coverage to all points on the earth at all times.

[63] Multiple sources exist for background information on GPS. For an historical account see *The Limitless Sky: Air Force Science and Technology Contributions to the Nation*, ed. Alexander Levis, 2004, 5-24. For a technical description of GPS see Elliott Kaplan, *Understanding GPS Principles and Applications* (Boston, MA: Artech House Publishing, 1996). For a discussion of GPS's role in past and future military operations see James Hasik and Michael Ripp, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis, MD: Naval Institute Press, 2002).

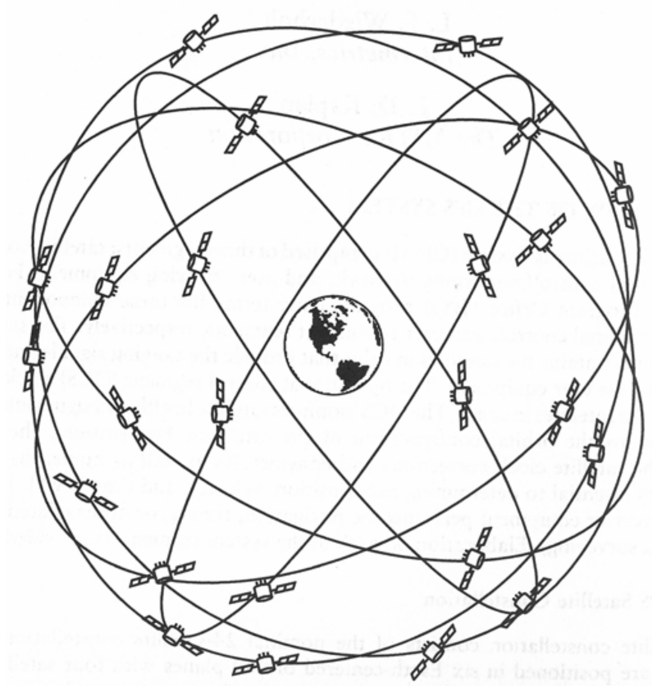

Figure 2--GPS constellation diagram

Source: Elliott Kaplan, *Understanding GPS Principles and Applications* (Boston, MA: Artech House Publishing, 1996), 60.

Accurate GPS data, however, requires each satellite to have precise clock and position information. This is accomplished by routinely updating each of the 27 satellites with current data. On average, updates for each satellite happen approximately twice a day, resulting in about 50 updates per day for the entire constellation. By modifying the schedule of satellite updates, the GPS system can produce *specific* effects to support to a particular area for a specific period of time. This particular capability is referred to as GPS Enhanced Theater Support (GETS).[64]

The GETS concept is simple. In a nutshell, any GPS satellite that flies over the supported theater during the specified period of support is updated with current clock and position data just prior to coming into view of the theater. As a result, all GPS satellites supporting the theater have the most current updates possible, which effectively increases the accuracy of the data delivered to a GPS receiver in that theater. The first

[64] See AFTTP 3-1.28 for a thorough description of the GETS tactic.

demonstration of this capability occurred during Operation Allied Force (OAF) in 1999, although it was not called GETS at the time.[65] Following OAF, after further testing, an operational tactic was developed and termed 'GPS Enhanced Theater Support', or 'GETS.'[66] GETS was employed extensively in support of combat operations in both OEF and OIF. It is important to note, however, that the net result of GETS does not increase the accuracy of the individual satellites beyond their inherent limitations, but rather it eliminates one of the primary sources of error; clock and positional drift errors that develop over time.

An example best illustrates the capabilities and limitations of GETS. Suppose that without using GETS, the accuracy of the GPS constellation over a theater was 3 meters Circular Error Probable (CEP). This means that if 100 GPS-aided munitions were dropped in that theater, all other factors equal, 50 percent of the bombs (50 bombs) would land within 3 meters of the target and 50 percent would land more than 3 meters from the target. Of those 50 that land more than 3 meters from the target, some may land as far as 20 meters from the target. This is where the benefit of GETS can be realized. Using GETS in the same scenario, the CEP of 3 meters does not improve, meaning that still only 50 percent of the bombs will still land within 3 meters. However, the average miss distance of the outlying errant bombs will be reduced. For example, the greatest miss distance of the 100 bombs may now be only 8 meters, instead of 20. So the benefit of GETS is not in its ability to put any particular bomb through a 2 foot by 2 foot window, but its ability to reduce the potential of collateral damage caused by an errant bomb hitting the building next door.

Numerous theses and after-action reports from every conflict since the first Gulf War document the benefits of GPS in modern warfare.[67] In fact, it is so critical to our operations that Iraqi forces employed GPS jammers during OIF to limit our ability to use

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[65] Lt Col Suzanne M. Beers, *Air War Over Serbia (AWOS) report, Aerospace Power in Operation Allied Force,* vol.2, sect. II, focus area 2, "Effect of Global Positioning System (GPS) Constellation Optimization" (U), 18 April 2000. (classified) Information extracted is unclassified.

[66] While GETS is officially a "tactic," it is not employed as a tactical action such as a series of maneuvers that a pilot might take to defeat a surface-to-air missile threat. The effects of GETS occur more at the operational level. It can be thought of as an "operational tactic," but it is referred to in this paper simply as a "tactic."

[67] James Hasik and Michael Ripp, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis, MD: Naval Institute Press, 2002).

it against them.[68] However, as critical as GPS is, it should be clear that GPS is not immediately directed at enemy forces but enhances friendly forces and capabilities.

GPS also produces both global and theater effects. GPS always maintains a minimum accuracy requirement for global users, yet through implementation of GETS, it can provide optimized effects in a specific theater, as described above. The resources required to implement GETS are not unlimited, however, and implementing GETS in one theater may very well preclude the ability to implement it in another theater, depending on the size of the theater and the duration of the GETS support. The limited resource here is the manpower needed to perform the additional satellite uploads. A larger support region greatly increases the number of satellite requiring uploads. Coupled with a long support duration, the manpower requirements needed to perform the uploads could easily exceed the manpower available to implement GETS in multiple theaters.

Perhaps more importantly, extended use of GETS can have negative consequences on GPS support outside the GETS-supported theater. The added number of uploads necessary to implement GETS increases wear and tear on ground equipment. During OEF and OIF, in order to perform the increased number of uploads, preventive maintenance on critical ground equipment and satellites had to be deferred, increasing the likelihood of a failure that would impact not only theater but global GPS users. This will be discussed in more detail in chapter 4, however, it is sufficient at this point to understand that global and theater effects can compete with each other. For this reason, the theater commander does not have tasking authority over GPS. Instead, the United States Strategic Command (USSTRATCOM), the combatant commander for space, adjudicates tasking requests and delegates tasking authority to the Fourteenth Air Force, the numbered air force for space.

The GPS example also serves as a useful tool to better understand the nature of space effects. It's obvious that GPS effects are non-kinetic. They are also systemic, in that they change the behavior of the friendly systems that use them. For example, they change the flight path of GPS-aided munitions, as they fall toward their targets. They also may change the path of ground troops who are using GPS to navigate across the

[68] Lt Gen Victor Renuart, "CENTCOM Charts Operation Iraqi Freedom Progress," Armed Forces Press Service, 25 March, 2003.

desert. The direct effect of GPS is a systemic effect on the friendly system it is supporting.

GPS is commonly mistaken as having a direct effect on the battlefield. Many think of the destruction of a target by a GPS-aided munition as the direct effect of GPS. This is incorrect. The Air Force Doctrine Commanders Center Handbook (AFDCH) 10-01, *Air and Space Commander's Handbook for the JFACC*, explains that "Direct effects are immediate, first-order effects (weapons employment results)."[69] The destruction of the target is the direct effect of the munition, not of GPS. Each GPS satellite, as a weapon system itself, has its own direct effect on the GPS-aided munition, but not on the target. Any effect on the target is a second-order (indirect) effect of GPS. First-order effects are direct, second-order effects are the first layer of indirect effects, third-order effects are the second layer of indirect effects, and so on.[70] There may be multiple levels of indirect effects, and the higher the order, the more difficult it is to link a cause to the effect.

> Current space forces are primarily characterized by their contribution to direct and indirect effects at the strategic, operational, and tactical levels of war. For instance, GPS signal accuracy increases the lethality of the Joint Direct Attack Munition (JDAM), a weapon capable of producing direct effects. The direct effects may range from tactical destruction of an enemy air C2 facility to the operational disruption of that enemy's air campaign. The indirect effect may include the strategic culmination of that adversary's offensive. Thus, the effect of JDAM employment, enhanced by GPS accuracy, has directly destroyed a vital enemy C2 facility while indirectly halting the enemy advance.[71]

This paragraph makes a key point that space forces *contribute* to the effects of others systems. It explains that GPS *increases the lethality* of JDAM, which ultimately produces the direct effects on the enemy. By contributing to the effects of other systems, space forces produce an indirect effect on the results of those systems, which may be at the strategic, operational, or tactical level of war. It should now be clear that space

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[69] Air Force Doctrine Center Handbook (AFDCH) 10-01, *Air and Space Commander's Handbook for the JFACC*, 16 January 2003, 64.
[70] AFDCH 10-01, 64.
[71] AFDD 2-2, 5.

effects generally contribute indirectly to operational level activities, and therefore, will usually be indirect effects. The difficulty in assessing these indirect effects will be in the determination of exactly what that contribution was and how effective it was.

Another characteristic of space effects discussed above is the fact that the same effects may apply to multiple users, thus creating multiple operational effects. Using our GPS example, the operational effect of disrupting enemy C2 capabilities (by enabling JDAMs) may be different than its effect on defeating enemy ground forces (by enabling friendly ground forces with navigational aids). An operational assessment of GPS operations must consider each activity it supported separately.

One final issue to consider is command and control of space assets. The Aerospace Operations Center (AOC) at Fourteenth Air Force tasks all global Air Force space assets on the authority of USSTRATCOM. As previously mentioned, the supported theater requests space support from Fourteenth Air Force through USSTRATCOM. During a conflict, it is customary that Fourteenth Air Force will have direct liaison authorized (DIRLAUTH) with the theater air component commander and his AOC, enabling the two to coordinate space support directly. For example, during OIF the Fourteenth Air Force AOC had DIRLAUTH with the Combined Air Operations Center (CAOC) at Prince Sultan Air Base (PSAB) in Saudi Arabia. The CAOC tasked nearly all air assets used in theater during OIF through the Air Tasking Order (ATO). On the other hand, Fourteenth Air Force tasked nearly all the space assets that supported OIF using the Space Tasking Order (STO) generated by the AOC. Tasking requests from the CAOC flowed formally through the respective combatant commands (U.S. Central Command and U.S. Strategic Command), but the coordination occurred directly between the theater CAOC and the Fourteenth Air Force AOC. The planning cycle that produced the STO was synchronized with the theater ATO cycle such that each day's STO supported the ATO for that same day. Assessment, which is part of the ATO and STO cycle, was a collaborative effort between the two operation centers, with the Fourteenth Air Force AOC responsible for combat (tactical assessment) and the theater CAOC responsible for operational assessment. A diagram of the ATO/STO parallel planning cycles is shown in figure 3.

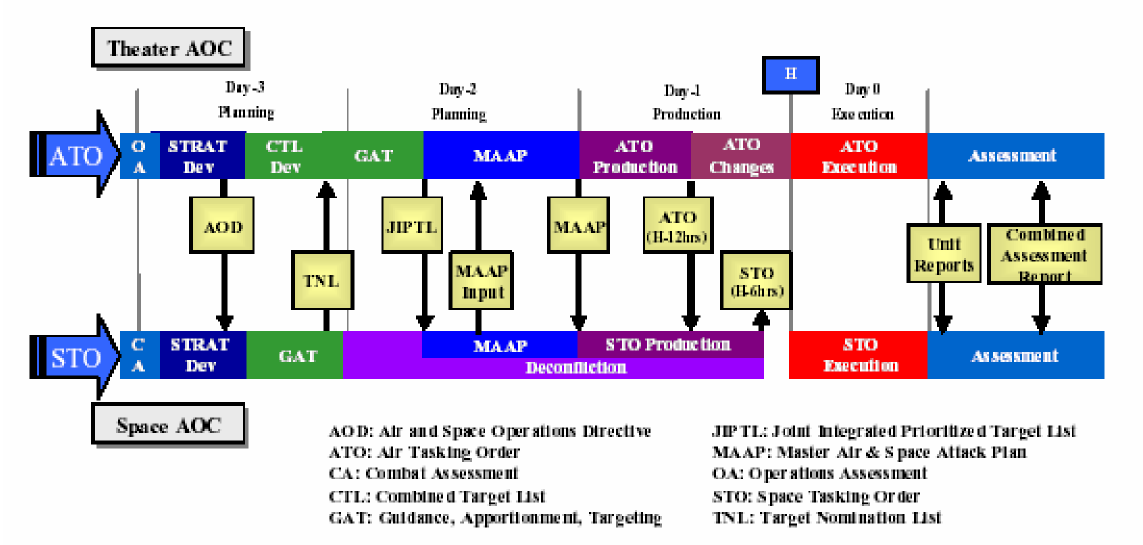

Figure 3--Notional Process for ATO/STO Synchronization

Source: AFDD 2-2.1, *Counterspace Operations*, 2 August, 2004, 38.

Space operations are certainly unique when compared to traditional air, land, or sea operations. It requires, as General Jumper said, "a unique respect for what it brings to the fight."[72] This necessitates the need for us to reassess how we think of effects. While the future may hold a more significant role for space in the future, at the current time it plays a support role. As such, the direct effects of space are non-kinetic, systemic, and at the tactical level or perhaps lower. The operational level effects of space are indirect, often very indirect, meaning multiple levels of warfare and enabling mechanisms separate the direct space effect and the actual operational effect. This makes the task of operationally assessing space operations a formidable one.

The next chapter will consider past experiences of air power and issues with assessment. The lessons learned from dealing with assessment provide insight into why assessing space is so difficult today.

[72] Gen John P. Jumper, "A Word from the Chief: Why 'Air and Space'?" Air and Space Power Journal 16, no. 3 (Fall 2002): 5. available from: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/fal02/jumper.html.

Chapter 3

Challenges Assessing Air Operations

This chapter takes a hard look at operational assessment. It begins with a breakdown of the components of operational assessment and describes some of the problems and issues associated with it. The remainder of the chapter provides historical examples of these problems. Since the use of space is still relatively new to warfare, only recent conflicts offer opportunities to observe space assessment directly. However, the Air Force has struggled with the assessment problem since World War One (as the Army Air Service) and frankly has not progressed much further since the Great War. Our past struggles to assess air power reveal lessons about the operational assessment problem in general; and some interesting parallels between space and both strategic bombing and close air support (CAS) enable us to apply some of these lessons directly to space assessment. Specifically, this chapter will discuss assessment issues encountered in World War II, Korea, Vietnam, and the Gulf War.

In some respects, space is very similar to strategic bombing. Much like space, the conduct of strategic bombing frequently has the achievement of indirect effects as its goal. Additionally, in the past, the integration of strategic bombing with other operations has been problematic. In other ways, space is comparable to CAS. CAS, like space, supports other organizations, in this case, Army and Marine Corps forces. CAS is also a resource-limited capability that has many customers competing for support. A final similarity worth noting is that during World War Two, Korea, Vietnam, and to some extent even today, CAS often suffers from a lack of integration with the operations it supports, due in part to the fact that the supported organizations have not fully understood how best to use it. Because of these similarities and their direct effect on the ability to perform an operational assessment, examinations of strategic bombing and CAS provide a body of evidence that shed light on space assessment issues today.

Components of Operational Assessment

Operational assessment consists of at least two key components. The first part determines whether you have achieved the desired operational effect (operational objective). The second part is to determine how the tactical tasks contributed to the accomplishment of the operational objective (or the failure to accomplish it). Simply put, one needs to know if one is winning (or not), and why one is winning (or not winning). These two components are addressed now in more detail.

The first component of operational assessment is to determine if the operational objective has been, or is being, achieved. There are no scores posted on a board in war and operational objectives are often not very quantifiable. Therefore, in lieu of measures of effectiveness, success indicators are often touted as a means to determine operational success. Qualitative in nature, success indicators should be identifiable and readily determine the achievement of operational objectives. For example, consider an operational objective to *gain and maintain air superiority*. There are no quantifiable measures that could effectively indicate that the objective has been met. Therefore, a success indicator would be used instead. An example of a success indicator might be "*Freedom to conduct air operations with impunity*." Using success indicators, military commanders may recognize when their own operational objectives are being achieved, even if they can't measure them. This first component of operational assessment, then, tells the commander if he is winning meeting an operational objective; it does not, however, tell him why, or why not.

The second component of operational assessment, and by far the most difficult, is tying the tactical assessments to the operational assessments. As previously discussed, the linkages are not as straightforward as the strategy-to-task methodology might lead one to believe. Tactical tasks have direct effects at the tactical level and are usually measurable. However, those tactical tasks also create higher-order effects at the operational level that are indirect and tend to be psychological, functional, or systemic in nature, rather than physical. As such, these indirect effects are extremely difficult to predict or even recognize, let alone accurately link to an operational objective. To

complicate matters more, these effects usually combine with other effects to create cumulative effects. Cumulative effects are particularly hard to assess since it is difficult to distinguish the individual contributions of each effect. Clausewitz explains, "all parts of a whole are interconnected and thus effects produced, however small their cause, must influence all subsequent military operations and modify their final outcome to some degree, however slight."[73] The task of identifying all the indirect effects and relating them to an operational objective, then, becomes unmanageable, if not impossible.

In short, while tactical assessment is concerned simply with knowing the tactical effects (i.e. the results of the tactical tasks), operational assessment is concerned not only with knowing the operational effect, but also with determining how the various tactical tasks contribute to the operational objective. One way of thinking about this is that tactical assessments determine the *effects* of tactical effects, while operational assessments determine the *effectiveness* of tactical tasks in achieving operational objectives. This, of course, requires an operational objective to start with, and then requires evidence that supports the effectiveness of the task in relation to that objective. As we will see, effectiveness against higher-order objectives becomes difficult as the effects become more indirect. In this sense, the strategic bombing analogy is appropriate.[74]

Before discussing attempts to assess the effectiveness of airpower in wars past, an important point should be made. There has been much debate over a significant portion of the last century regarding the most effective use of air power. Some have argued that support of the ground or naval forces represents the best use of air power. Early airpower

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[73] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1976), 158.

[74] Strategic bombing does not infer only the achievement of strategic objectives. Strategic bombing can support operational objectives through indirect effects. For example, the strategic bombing of aircraft manufacturing plants may support a strategic objective by affecting the will of people; however, at the same time it could support an operational objective of maintaining air superiority. Furthermore, the term "strategic bombing" has no universal definition within the military. References to strategic bombing vary in different manners, including the targets, precision, and desired effects. Furthermore, various definitions of the term have evolved over time with technology. David MacIsaac recognized the aversion by many writers and historians to define the term. Even the United States Strategic Bombing Survey (USSBS) went out of its way to avoid defining it. (David MacIsaac, "Introduction," in *Case Studies in Strategic Bombardment*, ed. R Cargill Hall (Washington D.C.: Government Printing Office, 1998), 6.) In this thesis, however, the term "strategic bombing" shall refer to aerial bombing of material or population targets deep within enemy territory with the intention of degrading the enemy's ability or will to continue the fight. Examples include Allied bombing of Germany during World War Two as well as the bombing of North Vietnam during the Vietnam War. Current Air Force vernacular for strategic bombing is "strategic attack."

advocates posited that independent operations of strategic bombing represented the best use of airpower. Even among the air advocates there was dissension. Some, most notably Giulio Douhet, believed it most effective to target civilian population centers, thereby destroying the will of the people.[75] Others, including American officers at the Air Corps Tactical School, insisted the best use of strategic bombing was to target the enemy's war-making capability by destroying factories and infrastructure.[76] Still others have argued for targeting enemy leadership directly with decapitation strikes.[77] As such, surveys and evidence have been collected and shaped to support these distinct theories on the most effective use of air power. However, when speaking of effectiveness, this work does not engage in the debate over the most effective use of air power. Rather, it addresses how to assess the effectiveness of air power against a particular objective, whatever that objective may be. Whether that objective reflects the most effective use of air power is irrelevant because it is the assessment process itself that is the crux of this work. With that understood, we turn to history.

Effects vs. Effectiveness: Lesson from Strategic Bombing

> *This worry about effectiveness versus effects is not a matter of mere academic concern.*
>
> \- *Gulf War Air Power Survey*

The concept of assessing *effectiveness* instead of *effects* is not new. David MacIsaac, wrote about the United States Strategic Bombing Survey

[75] Giulio Douhet, *The Command of the Air*, trans. Dino Ferrari (1942; new imprint, Washington D.C.: Office of Air Force History, 1983).
[76] William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power Economic and Military* (New York: Dover Publications, 1988).
[77] John A. Warden III, *The Air Campaign: Planning for Combat* (New York: Pergamon Press, 1989).

(USSBS)[78], the post-World War Two survey on the Allied strategic bombing campaign. The primary purpose of the USSBS was to determine the effectiveness of the strategic bombing campaigns against Germany and Japan. The USSBS attempted to link all the damage that the Allies did in Germany to the outcome of the war, but struggled to do so. MacIsaac explained, “to measure effectiveness, as opposed to effects, becomes a problem of such magnitude as to be impractical, requiring as it does the evaluation of an almost limitless number of decisions leading up to the attack order.”[79] He added, “Contributing to the difficulty in measuring effectiveness was the inability to separate the effects of air action from those of the other arms.”[80] In the end, MacIsaac found, “What the directors and those who sponsored the Survey really hoped to find was some precise measurement of the *effectiveness* of strategic bombing as an instrument of final victory. What they found they had to settle for, however, was the measure of *effects* rather than effectiveness.”[81] The very nature of strategic bombing makes it extremely difficult to assess.

Gian Gentile, author of *How Effective is Strategic Bombing?*, further substantiates this. Gentile, also addressing the issue of strategic bombing in World War Two, writes,

> Strategic bombing remained controversial because of the difficulty of proving its effectiveness…And evaluating the effects of strategic bombing on vital enemy targets is especially difficult because that evaluation requires not merely an assessment of physical damage but an analysis of the entire enemy system. In short, the overall effect of strategic bombing on the enemy has not often been immediately apparent, sometimes taking an extended period of time to manifest itself.[82]

Gentile reiterates many of MacIsaac’s thoughts on assessing strategic bombing and adds another important element—assessing indirect effects takes time.

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[78] United States Strategic Bombing Survey, Area Studies Division. Area Studies Division Report. (Washington D.C., Government Printing Office, 1946).
[79] David MacIsaac, *Strategic Bombing in World War Two, The Story of the United States Strategic Bombing Survey,* (New York: Garland Publishing, 1976) 162.
[80] Ibid.
[81] Ibid., 161.
[82] Gian P. Gentile, *How Effective is Strategic Bombing?* (New York: New York University Press, 2001), 2.

While it may be possible to assess the direct effects of a strategic bombing campaign shortly after execution, the indirect effects, which are critical to assessing effectiveness against operational objectives, may not be evident for a long time, if they are evident at all. For example, the majority of the data used in the USSBS came from on-site surveys and interviews conducted at the end of the war. This type of assessment is obviously only useful in improving operations for the next war.

Strategic bombing in Germany and in the Pacific theater during World War Two revealed its incredibly destructive power, particularly to civilian populations. That realization, coupled with the rising concern over the possibility of a full scale war with China, or worse yet, a nuclear war with the Soviet Union, seriously restricted the use strategic bombing in Korea and Vietnam. Although extensive surveys such as the USSBS never happened after the Korea or Vietnam wars, post-war interviews provide some insight, though subjective, into the Air Force's ability to assess the effectiveness of their strategic bombing efforts.

As limited as the bombing campaign was in Korea, it was fairly successful. Restricted from bombing north of the Yalu River, the Air Force struck targets in Korea with the intent of affecting the "morale of the civilian population actively engaged in the logistic support of the enemy forces."[83] Gen Otto Weyland, the commander of Far East Air Forces (FEAF), was convinced throughout the campaign that the bombings were doing what they set out to do and evidence suggests that the morale of the civilian population was effectively broken when North Korea signed the armistice.[84] For the most part, the bombing campaign in Korea had clear objectives and followed established doctrine.[85] Unfortunately, applying these positive lessons in Vietnam remained problematic.

[83] Robert F. Futrell, *The United States Air Forces in Korea, 1950-1953*, rev. ed. (Washington D.C.: Office of Air Force History, 1983), 516.
[84] R. J. Foot, "Nuclear Coercion and the Ending of the Korean Conflict," *International Security*, vol. 13, no. 3, 108.
[85] Thomas C. Hone, "Strategic Bombardment Constrained: Korea and Vietnam," in *Case Studies in Strategic Bombardment*, ed. R Cargill Hall (Washington D.C.: Government Printing Office, 1998), 517.

Much has been written on the failures of the strategic bombing effort in North Vietnam.[86] Like Korea, there were political restraints that limited the target set in Vietnam; however, one of the most significant problems was the lack of clear objectives. Politicians in Washington, namely President Johnson, who selected the targets and the timing, directed much of the strategic bombing campaign in the North. Not only did this limit the effectiveness of the campaign itself, but it severely hampered any efforts to assess its effectiveness. Although Vietnam consisted of the three major strategic bombing offensives (Rolling Thunder, Linebacker I, and Linebacker II), I will focus on Rolling Thunder and Linebacker II, since they provide positive and negative lessons for assessment, respectively.

The primary objective of Rolling Thunder had been to stop, or reduce, North Vietnamese support to the insurgents in the south.[87] However, over the four years of the offensive, the target set continually changed to the point where different people had different views about what the campaign was primarily designed to accomplish. Not surprisingly, then, there were conflicting views about the effectiveness of the campaign. Mark Clodfelter writes, "Those who directed Rolling Thunder had difficulty evaluating its effectiveness, and bias tainted most appraisals. To Johnson and his political advisors, the campaign was a qualified success; to air commanders, it was a qualified failure.[88] In addition to halting North Vietnamese support to the South, various other objectives including demonstrating United States resolve, increasing morale in the South, and degrading morale in the North to drive them to the peace table, were goals of the campaign.[89] Different people had different perceptions of effectiveness against different objectives. While Johnson and his advisors believed that Rolling Thunder had successfully slowed the infiltration of insurgents and increased morale in the South, air commanders insisted it was a failure. According to Clodfelter, "By destroying the vital elements of the Northern industry, air leaders hoped to gain the unconditional triumph promised by Air Force strategic bombing doctrine. Bombing would, they maintained,

[86] Among the many notable works, see Robert A. Pape, *Bombing To Win* (Ithaca, N.Y.: Cornell University Press, 1996), Marc J. Gilbert, *Why The North Won The Vietnam War* (New York: Palgrave, 2002), and Mark Clodfelter, *The Limits Of Air Power* (New York: Simon and Schuster, 1989).
[87] Mark Clodfelter, *The Limits Of Air Power* (New York: Simon and Schuster, 1989), 76.
[88] Ibid., 142.
[89] Ibid., 144.

wreck the Northern economy and compel Hanoi to end the war."[90] Clearly there were different perceptions about the purpose of the bombings which led to different assessments of effectiveness.

Most analyses deemed the Linebacker II offensive a success. Linebacker II succeeded where Rolling Thunder failed because President Nixon, having replaced Johnson, was very clear about the objective of the campaign: "a large-scale air power attack against strategic targets centered in Hanoi and Haiphong to compel the North Vietnamese leadership to accept a cease-fire and thus allow American forces to withdraw from South Vietnam."[91] Working to that end, the Air Force commenced a heavy, persistent bombing campaign, similar to that conducted in North Korea. The campaign would last only nine days, as the North Vietnamese quickly agreed to negotiate a settlement to end the war. The more limited and focused objectives of the campaign lent themselves to better assessment of success or failure. Consequently, military and civilian leaders alike agreed on the effectiveness of Linebacker II. "Many leaders believed that Linebacker vindicated not only strategic bombing as a political tool, but also the tenets of Air Force bombing doctrine."[92]

While it is acceptable, and at times necessary, for activities to support multiple objectives, it is critical to clearly spell out the objectives in the plan and then assess each activity separately against each objective. The Air Force experiences in Korea and Vietnam provided a valuable lesson for assessment; to fairly and accurately assess the effectiveness of an activity, one needs to understand the objective that the activity was intended to support. Although this lesson applies to the assessment of all military activities, it is a special applicability for assessing space assets, which are too infrequently tasked against specific higher-level objectives.

Few would disagree with the fact that the Persian Gulf War in 1991 demonstrated marked improvement over Vietnam with respect to having clear objectives. Yet, the assessment problem persisted. There was still a tendency to assess tactical effects (in the form of BDA) instead of assessing effectiveness at the operational level. The best

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[90] Ibid.

[19] Gian P. Gentile, *How Effective is Strategic Bombing?* (New York: New York University Press, 2001), 169.

[20] Ibid., 201.

account of this comes from the Joint Force Commander, Gen Norman Schwarzkopf, himself.

> After two weeks of war, my instincts and experience told me that we'd bombed most of our strategic targets enough to accomplish our campaign objectives; it was now time, I thought, to shift most of our air power onto the army we were about to face in battle. But our experts, a team of "battle damage assessment" specialists…had us going in circles. They'd say things like' "You failed to destroy the power plant in Baghdad"; yet we knew that in Baghdad the lights were out….
>
> Battle damage assessment had traditionally been an art: analysts pieced together pilot reports, bombsight photos, reports from follow-up aerial reconnaissance, and the bits of information that trickled in from behind enemy lines. But the intelligence community had been trying to turn it into a science for years, primarily by spending billions of dollars on surveillance technology. Analysts had accordingly been trained to depend largely on "hard" evidence collected by reconnaissance planes and satellites. So if a pilot came back and said, "The bunker blew up before my eyes," they gave it no credence: pilot reports, they maintained, were always exaggerated. But their equipment wasn't as all-seeing as they thought, and they'd left themselves no leeway to exercise military judgment. So while their analyses were sometimes superb, just as often they made no sense in terms of the criteria I'd defined for assessing damage to enemy installations, units, and equipment. We couldn't afford distorted assessments: too much optimism could prompt us to launch the ground war too soon, at the cost of many lives; too much pessimism could cause us to sit wringing our hands and moaning that the enemy was still too strong.[93]

As Schwarzkopf articulated, technological advances since Vietnam led to overdependence on hard evidence by the assessment community, resulting in too much focus on BDA, and too little on operational assessment. Recognizing the problem, the Gulf War Air Power Survey (GWAPS) reported, "Assessments of military effectiveness cannot, therefore, be reduced to the amounts of physical damage or destruction inflicted on targets, the quantities of military equipment damaged or destroyed, or even to the numbers of combatants directly wounded or killed. Instead, issues of operational-

[93] Norman H. Schwarzkopf, *It Doesn't Take a Hero* (New York: Bantam Books, 1992), 498-499.
[22] Barry D. Watts and Dr. Thomas A Keaney, *Gulf War Air Power Survey (GWAPS)*, vol. 2, part 2, "Effects and Effectiveness" (Washington D.C.: Government Printing Office, 1993), 28.

strategic effectiveness will also necessarily involve human plans, intentions, psychology, political ends, and other hard-to-quantify factors and considerations."[94]

Strategic bombing experiences in World War II, Korea, Vietnam, and the Gulf War provide several important lessons about assessing indirect effects. David MacIsaac's criticism of the USSBS that followed World War II brought to light the fact that assessing effectiveness resulting from indirect effects is difficult for several reasons. Indirect effects are inherently hard to identify and equally hard to distinguish from other effects. In addition, there are usually delays associated with indirect effects. As a result of these delays, assessment may not be possible until long after the causing event occurred. Finally, since the desired indirect effect is often psychological, resulting in a change in the enemy's behavior, it may require inside knowledge of enemy thought processes. The lessons in Korea and Vietnam highlight the point that causes can only be fairly assessed against the intended effect, or objective. This, of course, requires that actions are tasked against a clearly stated objective; something that was done much better in Korea than in Vietnam. Finally, the GWAPS report after the Gulf War captured General Schwarzkopf's evaluation that the assessment community was too focused on BDA on not enough on operational assessment. The report, however, recognized that the assessment problems are not easily remedied. Both MacIsaac and the GWAPS point out the problems without offering any real solutions. They do, however, remind us that if we want to find the keys, we need to start feeling around in the dark rather than looking where the light is good.

The current version of AFDD 2-1.2, *Strategic Attack*, recognizes the problems with assessing indirect effects and addresses the issue directly:

> Planners, commanders, and analysts may not know the impact of strategic attacks immediately because they most often work through psychological, systemic, cascading, or other higher-order effects. Therefore, successful strategic attack may depend on anticipatory operational and campaign assessment done as part of planning. Accurate assessment provides the groundwork for analysts to determine how well the plan is developing during execution. This is even more the case for strategic attack operations than for many other types of force application because the

> subjective and sometimes tenuous linkage between cause and effect may make intermediate steps in the effects chain hard to detect and this may lead to the false impression that particular operations are ineffective.[95]

Alternatively, it could lead to the false impression that particular operations are *effective*, leading to the continuation of activities that are ineffective, while potentially denying the use of those resources where they may be more effective. The doctrine brings out another important point; the inability to immediately assess strategic bombing may require "anticipatory operational and campaign assessment done as part of planning."[96] If so, successful planning will rely on an extensive assessment from previous operations. This lesson is equally relevant to the space community as will be shown in subsequent chapters.

To this point, it ought to be clear that operational assessment should determine the effectiveness of tactical tasks in achieving operational objectives. However, the definition of *effectiveness* may depend on one's perspective. Different perspectives offer unique understandings of effectiveness, which leads to the important question of which perspective is the correct perspective? This is an important issue since the wrong measures of effectiveness can seriously undermine the operational assessment process. This is the subject of the next section.

Effectiveness vs. Efficiency: Lessons from Close Air Support

> *An enormous quantity of data described the Air Force's effort, but little its progress, in South Vietnam*
>
> \- *John Schlight*

The discussion of strategy-to-task methodology in the first chapter did not distinguish between cases where the organization that *owns* the operational objective is the same organization performing the supporting tactical task, and the situation where a different organization is performing the task. In the baseball example, obviously the team performing the tactical tasks of pitching,

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[95] AFDD 2-1.2, 25.
[96] AFDD 2-1.2, 25.

hitting, and fielding, is the same team that wins or loses the game (whichever the case may be). In the military example, however, the Air Force owns the operational objective of *achieving air superiority*, but the Army owns the task of *defending friendly assets from air attack* through the employment of SAMs & AAA. In this case, the Air Force would be the supported organization, while the Army plays the supporting role. In a supporting/supported relationship such as this, it is useful to think of the supported organization as a *consumer*, the supporting organization as a *producer*, and the tasks performed as a *product*. The distinction between a consumer and a producer is extremely relevant to the discussion of operational assessment in that in many cases the definition of effectiveness depends greatly on whether one is a consumer or a producer.

The producer often has a fairly limited view of the higher-level effect the product is having. For example, the Army forces operating the SAM and AAA sites defend friendly assets from air attack. However, the Army is in no position to assess whether the higher-level objective of achieving air superiority has been accomplished. As the consumer of the product, the Air Force is best suited to determine the veracity of that issue. Without insight into the *effectiveness* of the product, the producer tends to focus on the *efficiency* aspects of the product. The measure of *how well* is replaced by measures such as *how many*, *how fast, or how cheaply*. The consumer, on the other hand, tends to be focused primarily on the assessing the *how well*, or the *effectiveness*, as it relates to his operational objective. Since the producer is concerned with efficiency and the consumer is concerned with effectiveness, the two may have very different assessments of the task performed.

When resources are limited, as they usually are in war, efficiency and effectiveness compete with each other. Though not mutually exclusive, one usually comes at the expense of the other. At one extreme, efficiency is about meeting some effectiveness standard with the minimum amount of resources required, freeing the remaining resources for employment elsewhere. At the other extreme, effectiveness is about maximizing the result with little concern for the resources required. Producers and consumers, as a result, have competing

perspectives. Due to these different perspectives, producers and consumers use different criteria to evaluate the product, and the two may come to very different conclusions about its effectiveness. Therefore, it is important for both the producer and the consumer to understand the single objective of the task and to share the information necessary to assess its effectiveness. While the two may still have different assessments of the effectiveness of the task, in the end, the final word should come from the consumer who owns the operational objective. An examination of CAS operations in Vietnam can illustrate the importance of perspective.

In South Vietnam, the Air Force dedicated many resources to CAS, though the service was not fully aware of the objectives they were supporting. Used primarily in an on-call capacity, they simply got requests for support from the Army and struck the target coordinates as quickly as they could. Not only did the Air Force not understand how their efforts affected Army ground operations, at times they had little knowledge of whether or not they hit their targets because of the "jungle canopy."[97] John Schlight writes:

> One of the larger disappointments of the war was the inability to measure closely the results of air strikes. Lacking quantifiable data, analysis of the Air Force's effectiveness was extraordinarily difficult. Effectiveness is determined by establishing an objective, devising a set of criteria to measure against, and gathering enough facts to see if these criteria have been satisfied. In South Vietnam, the Air Force possessed neither its own war objectives nor enough reliable data to quantify the results.[98]

Since the Air Force was often not informed of the objectives they were supporting, they were not in a position of assess the operational effectiveness of the CAS. As a result, they assessed CAS against objectives they contrived themselves. Phillip Meilinger described the problem this way:

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[97] John Schlight, *The War in South Vietnam: The Years of the Offensive, 1965-1968* (Washington D.C.: Government Printing Office, 1988, 130.
[98] Ibid., 129.

> Because the Army selected all targets based on a ground situation they alone saw, the MOEs for the air strikes were not clear. Airmen therefore invented their own: the army wanted a truck struck, and if it was, the mission was declared a success…Vietnam became an exercise in counting—sorties, bomb tonnage, jungle trails cut, trucks destroyed, bridge spans dropped, and water buffalo killed—water buffalo could be used for transportation. As so often occurs in such situations, the drive to gather data and indeed to *generate* data became an end in itself…In essence, the task of the USAF was merely to service a list of targets for the Army. The MOE thus became a determination of how quickly, effectively, and efficiently airmen were able to service that list.[99]

Certainly, the ground force commander was in the best position to assess the true effectiveness of the CAS. However, as Schlight writes, "Frequently Air Force strike aircraft were joined by Army helicopters; VNAF, Navy, and Marine planes; and by ground artillery, troops, and armor in assailing the same target. Under such circumstances, no one could tell which of the participating weapons inflicted casualties or persuaded (or failed to persuade) the enemy to disengage."[100] This issue is a common problem associated with effects, especially indirect effects. They are very difficult to distinguish from other effects, hence making it nearly impossible to accurately assess the effectiveness of individual contributions. In the end, the Army could not distinguish the effects of the Air Force CAS, and the Air Force neither understood the objective they were supporting nor had the data to assess effectiveness. The resulting assessment from the Air Force was actually a measure of efficiency, and suggested nothing of effectiveness. This is a common problem today with Air Force assessments of space operations and further analysis of the issue is in chapter 4.

Although better integration of air and ground operations was a hallmark of the Gulf War, the assessment issues rang familiar. In Iraq, the air forces were under the command of Lt Gen Charles Horner, the Joint Force Air Component Commander (JFACC), while General Schwarzkopf, who was dual-hatted as both

[99] Phillip Meilinger, "A History of Effects-Based Air Operations," *RAF Air Power Review*, Autumn 2003, 18.
[100] Schlight, *War in South Vietnam*, 130; Vietnamese Armed Forces, also called RVNAF (Republic of Vietnam Armed Forces).

the Joint Force Land Component Commander (JFLCC) and the overall Joint Force Commander, commanded the ground forces. The GWAPS documented:

> …the lack of agreement on how to calculate BDA caused endless problems, not the least of which was the divergence between air force targeting and army BDA. Many Coalition sorties attacked truck convoys, ammunition dumps, and other targets in the enemy's supply network. How should one evaluate such sorties? What did their BDA mean in terms of a future ground war?[101] These were vexing problems with which commanders had to wrestle but could never fully resolve. Ultimately, it was the assessments imposed by Schwarzkopf that ended much of the argument on BDA.[102]

According to the GWAPS, General Schwarzkopf gave little credence to the BDA reports. He preferred the number of air strikes against Iraqi troops as a better indicator than the amount of damage reported; fewer air strikes meant there were fewer targets to hit, which meant that the Iraqi ground forces were diminishing in size and effectiveness. "For his part, Horner resolved to stay out of bomb-damage assessment (BDA) fights altogether. Since BDA against the Iraqi field army was an army concern, he expected the army to address the problem."[103]

Although this was not CAS (since the ground war had not started yet), it resembles the CAS assessment problems in Vietnam and seems to indicate that both Schwarzkopf and Horner understood the lessons learned from that war. Schwarzkopf used his own subjective criteria to assess the effectiveness of the air support. Horner provided what information he had, but deferred the actual assessment to Schwarzkopf who was the consumer of the air support.

Throughout the campaign, Schwarzkopf used his own subjective methods to assess BDA, just as he had for assessing damage to strategic targets (discussed earlier). GWAPS concluded:

> In the end, Schwarzkopf played a crucial role in the assessment process…Ultimately it was not the amount of damage to Iraqi military equipment that mattered, but rather the damage done to the minds of the Iraqi soldiers. And so Schwarzkopf determined how CENTCOM would

[101] Since the air war preceded the ground war in Iraq, an accurate assessment of the progress of the air war was critical in determining when the ground campaign should begin.

[102] Dr. Williamson Murray, *Gulf War Air Power Survey (GWAPS)*, vol. 2, part 1, "Operations" (Washington D.C.: Government Printing Office, 1993), 262.

[103] Ibid.

> assess the strength of each individual Iraqi unit; his criteria were as much subjective as objective. However, as the ground war would prove, his estimates were closer to the mark in estimating Iraqi fighting power than were those based on various "objective" measures.[104]

The Gulf War successfully demonstrated, among other things, that the consumer of air support should ultimately be responsible for assessing its effectiveness. This idea certainly has implication for assessing space. In addition, Schwarzkopf's use of subjective data for assessment in addition to BDA reports, demonstrate the potential value of subjective, qualitative assessments. This is the subject of the final section of this chapter.

[104] Ibid., 283.

The Value of Subjective, Qualitative Assessments

Those who speak most of progress measure it by quantity and not by quality.

- George Santayana

Subjective, qualitative assessments can at times be the best real indicators of operational effectiveness. However, there are two problems with these types of assessment. First, for operational assessment to be useful, it must be available during the actual combat portion of the war. Unfortunately, this type of evidence is often only available after the war has ended. In the heat of battle, those involved in the war may not have the wider perspective or all the information necessary to give an accurate assessment. Secondly, subjective assessments derived during the conflict are likely to be highly biased. Nevertheless, this type of assessment can be invaluable because, even if it is not always timely, it often provides some of the best indicators of success for both strategic bombing and close air support. The following evidence, once again drawing from American experiences in Korea and Vietnam, illustrates some of the issues and usefulness of subjective, qualitative assessment.

No matter how effective Air Force close air support was in the early stages of the conflict in Korea, it never could have lived up the Army's expectation. Army ground commanders complained bitterly about CAS.[105] Given the difference in perspectives, it is not unexpected that the Air Force, as a CAS producer, and the Army, as a CAS consumer, would debate the amount of CAS support the Air Force gave to the CAS mission. However, service rivalry and politics exaggerated the biases even more. The Korean War was the first war fought after the Air Force became a separate service. Prior to Korea, the Army

[105] Allan R. Millett, "Korea, 1950-1953," in *Case Studies in the Development of Close Air Support,* ed. Benjamin Cooling, (Washington: Office of Air Force History, 1990), 345-410.

conducted its own CAS. When the Air Force became independent in 1947, they "took" the CAS mission from the Army. One of the chief complaints of the Army was that the Air Force did not make sufficient aircraft available for CAS and had a lack of interest in the mission.[106] An Air Force report, on the other hand, "gave the Air Force generally high marks."[107]

The difference of opinions between the Air Force and the Army essentially boiled down to CAS priority. To Army ground commanders, CAS should have been the highest priority of the Air Force. To the Air Force, interdiction was an equal or higher priority than CAS.[108] The combination of a difference in perspectives between the CAS provider and consumer, coupled with service bias resulted in a highly unfavorable environment for honest, subjective assessment during the war. It wasn't until late in the war that the two services finally came to agreement on the priority of CAS. The service bias problem was further exacerbated by the Marine Corps involvement in the CAS mission. Marine Corps aircraft supported Army forces as well as their own forces on the ground and operated independent of the Air Force CAS system. Differences the between the types of aircraft used, the command and control structure, and type of alert (airborne vs. strip) led to further disputes between the Air Force and the Army over CAS. Although the Marine and Army ground forces favored Marine air support, inquiries conducted during the war vindicated the Air Force system as a whole. To prevent the recurrence of such feuds today and in the future, the JFC should resolve the issues of priority during the planning phase (in the strategy-to-task process) and exercise the command and control through joint training exercises. Still, one should expect the natural influence of service bias to have some degree of influence on subjective feedback during the war.

The ideal feedback, however, came from the ultimate consumer of CAS, the Chinese Army. Allan Millett documented that "As Communist generals testified later in the year, close air support ruined their offensive, and Chinese

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[106] Conrad Crane, *American Airpower Strategy in Korea, 1950-1953* (Lawrence, Kans.: University Press of Kansas, 2000), 60.
[107] Ibid., 61.
[108] Millett, 345-410.

prisoners taken in the spring of 1951 blamed their defeat on the continual air strikes they had to endure."[109] From the Chinese perspective, CAS was not only effective, but decisive. This assessment, though strictly qualitative, perhaps provides the best assessment of actual effectiveness. Millett's analysis shows the convincing nature of qualitative assessments. The difficult part is getting this kind of feedback when needed the most, during the war. In addition, he implies that in order to truly assess the effectiveness of a task, one should step back and assess it in the context of the objective tasked for support. Subjective, qualitative assessments have the potential to provide a perspective that may not be available using objective, measurable means. As long as the assessment community understands the potential for biases, these types of assessments are invaluable. When used to assess space activities, these types of assessments may be even more valuable, since the consumer of space support is a friendly resource and generally available.

By Vietnam, much of the interservice battle between the Army and the Air Force over CAS had settled down. Even though the inherent battles between consumer and producer were present, the overwhelming consensus indicated that CAS was very effective in Vietnam. John Schlight writes, "Even though results of the tactical strike effort often eluded quantification, individual instances of its effectiveness emerged from special studies and from the testimony of its consumers. There was widespread agreement among these sources that air power was the decisive factor in frustrating the enemy's determined offensive early in the spring and summer of 1965."[110] Later that year, CAS enabled the Army to defeat the enemy at a fort at Plei Mei. According to Schlight, "Only air power stood between the garrison and its attackers during the first 3 days, and the United States was able to deploy its ground forces behind this aerial shield. General Westmoreland and other U.S. and South Vietnamese military leaders

[109] Ibid., 379.
[110] Schlight, 291.

credited air power with making this deployment possible."[111] Westmoreland later rated CAS in Vietnam as "the finest any Army could hope to get."[112]

Given the luxury of being able to look back at the Vietnam War and interview people, John Sbrega attempted to assess the effectiveness of CAS. Sbrega wrote, "Assessing the role of close air support in the war remains an elusive task…One measure would be its impact on the way the war in South Vietnam was fought. Within, this context, close air support operations seemed to have a profound effect."[113] He observed how over the course of the war ground commanders became increasingly dependent on CAS. According to Sbrega, one Army ground force commander admitted, "I learned after a while that my casualties were tremendously decreased if I used the air power and air strikes and used it properly."[114] He concluded, "Despite all variables and extenuating circumstances, in the final analysis the true test of close air-support operations is how well they satisfied the requirements of the ground force commander. Judging from the favorable reactions of ground commanders throughout the war—at least during the "American phase" of the war—close air support met that overriding goal."[115]

This chapter has identified many of the problems associated with indirect effects that are common with space activities. The lessons learned from strategic bombing served as a good analogy to space for indirect effects. The latest AFDD 2-1.2 document accurately states: "While direct, physical effects normally provide key indicators for measuring the success or effectiveness of an operation, the indirect effects are most important for the strategic attack effort and are harder to measure, relying upon qualitative and subjective measures of effectiveness, not quantitative and empirical measures of performance. This will continue to present significant challenges to analysts for the foreseeable future."[116] The chapter also brought up issues associated with a support-type relationship where there is a

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[111] Ibid., 292.
[112] John J. Sbrega, "Southeast Asia," in *Case Studies in the Development of Close Air Support,* ed. Benjamin Cooling, (Washington: Office of Air Force History, 1990), 470.
[113] Ibid., 469.
[114] Ibid.
[115] Ibid., 473.
[116] AFDD 2-1.2, 24.

producer and a consumer and used lessons learned from CAS to illustrate. It suggests that, in general, the consumer should have the responsibility for assessment, although it cannot be done in a vacuum without the aid of the producer. The final section highlighted the usefulness of subjective, qualitative data. Though it has the potential to contain biases, it can also be one of the best sources of assessment data.

The problems discussed in this chapter may lead one to believe that operational assessment is as much an art as it is a science. This is true to a large extent. While the scientific method provides a useful framework for understanding assessment, in the end, operational assessment is not generally conducive to hard evidence and scientific conclusion, and linking causes and effects usually comes down to subjective, qualitative data. Returning briefly to Clausewitz, a causal theory will always have a gap in evidence. Clausewitz says that the theory simply requires that one narrows that gap as much as possible. He warns, however, at that point one must suspend judgment. In the realm of science this may be good advice; but putting the theory into practice, requires one to use judgment. As Clausewitz goes on to say: "A critic should never use the results of theory as laws and standards, but only—as the soldier does—as *aids to judgment*."[117] Therefore, while scientific methods may serve as the basis of the theory itself; the process of using the theory to aid in judgment, which we call *assessment*, requires art. General Schwarzkopf defined assessment as an art, while warning about ongoing attempts to turn it into a science.[118] The bottom line is this: assessment is the art of applying scientifically developed theories.

To this point, all the discussion of operational assessment can apply across the board to all types of operations. However, each of the findings in this chapter has important implications for conducting an operational assessment of space activities. The next chapter, therefore, will apply what has been learned in this chapter specifically to space operations.

[117] Clausewitz, 158.
[118] Schwarzkopf, 499.

Chapter 4

Challenges Assessing Space Operations

Although the United States has been in the space business for over 50 years, military use of space had been reserved primarily for strategic purposes until the Gulf War in 1991.[119] Even then, most military users were not familiar with what space-based force enhancement capabilities existed or how best to employ them.[120] In many ways, space operations in the first Gulf War resembled air operations in World War I--relatively new and not well integrated, yet showing great promise. The first concerted effort to integrate space into large-scale air and ground operations did not occur until Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF). Consequently, it should not be surprising that the Air Force experienced the same assessment issues with space during OEF and OIF that they encountered assessing air operations in Korea and Vietnam, the wars that followed World War Two. This chapter will look at space operations (specifically GPS operations) from Operation Desert Storm through Operation Iraqi Freedom, focusing on how these space operations were tasked and assessed, what was not assessed, and how operational assessment is critical to determining how various space operations should be used in the future.

The unique characteristics of space previously identified in chapter 2 apply to most space assets that perform a force enhancement mission (reconnaissance, communication, warning, weather, etc). However, each force enhancement mission area is distinctive, as is the task of assessing it. Therefore, it is not feasible to attempt to address multiple mission areas in this chapter. Instead, this chapter deals with one aspect of space operations, from which lessons learned apply to all aspects of space operations. GPS is a good candidate for this study in that it typifies most space support missions with its indirect effects and global nature. Furthermore, the GPS Enhanced Theater Support (GETS) capability also provides a theater-specific mission that presents interesting issues

[119] William E. Burrows, *This New Ocean* (New York: Modern Library, 1998) and Paul B. Stares, *Space and National Security* (Washington, D.C.: The Brookings Institution, 1987), 45-72.
[120] Lt Gen Thomas S. Moorman, Jr., "Space: A New Strategic Frontier," *Airpower Journal*, Spring 1992, 14-23.

regarding the tasking and assessment of space. Therefore, this chapter will discuss space operations in general, but will provide specific examples using GPS to illustrate the points.

GPS Assessment in Operation Desert Storm

Many consider Desert Storm the "first space war" because it was really the first war that used space assets to support theater commanders directly, while concurrently filling their more traditional strategic roles.[121] As mentioned, however, space was not well integrated, nor were the users familiar with space or adequately trained on the use of space. An Air Force Space Command "hot wash" report in July of 1991 called Desert Storm "a 'come as you are' space war," where "troops were not as prepared as possible." The report recommended, "Equipment must be integrated in the operator's force structure before the hostilities erupt."[122] Another report recorded, "Space forces were there when required, but significant effort was needed to optimize their effectiveness…the capabilities of these systems must be thoroughly ingrained in our peacetime planning and training if we hope to exploit them fully in crisis or combat."[123] United States ground forces originally deployed with only a few hundred GPS receivers and little to no training on the system.[124] Although several thousand additional receivers were eventually sent to theater, forces did not understand the utility of GPS, nor had they trained with, or planned for its use.[125] Additionally, the space capabilities themselves were still being developed and deployed. At the breakout of hostilities in Desert Storm the GPS system was still considered an experimental system with only 16 satellites (a fully capable constellation

[121] Sir Peter Anson and Dennis Cummings, "The First Space War: The Contribution of Satellites to the Gulf War," *The First Information War*, (AFCEA International Press, October 1992).
[122] *Desert Storm "Hot Wash"*, Air Force Space Command, 13 July 1991, 2. Document is now declassified.
[123] Air Force Space Command, *Employment of Space Forces in Operation Desert Shield and Desert Storm* (U), (Colorado Springs, CO: HQ AFSPC/HO, 1991),1. (classified) Information extracted is unclassified.
[124] James Hasik and Michael Ripp, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis, MD: Naval Institute Press, 2002), 135.
[125] Maj Teresa R. Clark et al., *Gulf War Air Power Survey (GWAPS)*, vol. 4, part 2, "Space Operations" (Washington D.C.: Government Printing Office, 1993), 125-126.

requires a minimum of 24 satellites).[126] Initial Operational Capability (IOC) would not come for nearly three more years (December 1993), and Full Operational Capability (FOC) was five years away (27 April 1995).[127] As beneficial as space proved to be during Desert Storm, planners and users incorporated it in an ad hoc fashion. Space capabilities were clearly "pushed" to the users at the start of the war rather than integrated into the campaign during the planning phase. As a result, there was no strategy-to-task process by which to assess space operations (space tasks) against higher-level objectives.

Hampered by the lack of operational objectives for space, the Gulf War Air Power Survey (GWAPS) set out to assess space operations. The report attempted to focus on the operational impact of space operations during the war, and recognized, "it was necessary to cross functional boundaries and depart from the pure 'space story'…the true value of space support must be measured in terms of concrete warfighting results."[128] One of the difficulties with assessing space during Desert Storm was gathering operational assessment data from the space *consumers*. Not only were the consumers unfamiliar with how best to employ space assets (like GPS), at times they were not aware that they were even using space assets.[129] Without a strategy-to-task methodology, and given that the majority of users were unfamiliar with space and had little or no idea what it was capable of doing, only tactical assessments were available. So while tactical assessments were conducted that demonstrated the ability of GPS to put bombs on their target, operational assessments to determine the overall effectiveness of the capability against pre-determined higher-level objectives were not possible.[130]

Even without operational objectives for space, it was obvious that space operations had been effective in Desert Storm. The question is, "How effective?" The answer to the question of effectiveness depends on one's definition of *effective*, and how well one can link the cause and the effect. Furthermore, the term *effective* depends on ones perspective. Effectiveness must consider all the effects produced by the activity: direct

[126] Hasik and Ripp, 134.
[127] Ibid., 69.
[128] Maj Teresa R. Clark et al., vi.
[129] Ibid., vii. The report uses satellite communications as an example. Many users, it claims, were not aware they were talking via satellite.
[130] Maj Teresa R. Clark et al.; Hasik and Ripp.

and indirect; intended and unintended. For example, missions such as missile warning, communications, or reconnaissance have tactical, operational, and strategic missions. There were unintended effects, or *strategic* costs, associated with using those systems to support theater commanders. The theater commander might assess the effectiveness of missile warning satellites by his tactical or operational assessments alone. The space community, on the other hand, may have a broader perspective and determine effectiveness by weighing intended effects (the benefit of theater ballistic missile warning) against the unintended effects (the cost to strategic missile warning). At the end of the day, *effectiveness* depends on how well the cumulative effect resembles the desired *effect*, which is the objective.

GPS is not discussed in the above paragraph as it is a bit of an anomaly compared to the other force enhancement missions; using GPS in-theater did not hinder other uses of GPS. GPS tactics were employed in Operation Allied Force and subsequent wars which did have unintended effects, but for the purposes of Desert Storm, any benefit of using GPS could be considered effective since there were no readily apparent adverse effects.

GPS was a significant factor in nearly every type of operation in Desert Storm. Among other applications, GPS enabled precision bombing at night or in bad weather (including during frequent sandstorms in the desert)[131], allowed ground forces to navigate across an unmapped desert[132], and facilitated the Navy's ability to mark mines at sea.[133] The Joint Force Air Component Commander, Gen Charles Horner, declared after Desert Storm, "We have just begun to figure out the doctrines, the tactics and the procedures for all our operations—land, sea, and air—with regard to GPS."[134] While it may have been difficult to accurately assess the effectiveness of GPS in Desert Storm, the positive effects created on the battlefield secured the role of GPS in future operations. One thing is clear—during Desert Storm, GPS (and all space-based force enhancement operations) earned its rightful place in future wars, much like air power in World War One. Lee

[131] John Burgess, "Satellites' Gaze Provides New Look at War," *The Washington Post*, 19 February 1991, A13.
[132] Molly Moore, "US Training, Tactics Shift With Desert Sand," *The Washington Post*, 25 November 1990, A25.
[133] "DoD Quickly Buys Commercial GPS Terminals for Desert Shield," *Aerospace Daily*, 27 August 1990, 331.
[134] Gen Charles A. Horner, Remarks to the Northern Lights Software Associates (NLSA) Industry Days, Peterson AFB, CO, 7 July 1992.

Kennett wrote in his book, *The First Air War*, "While the role of the air weapon in the Great War was a modest one, the role of the Great War in the rise of air power was anything but modest."[135] The same can be said of GPS in the "first space war."

GPS Assessment in Operation Allied Force

The eight years that followed Desert Storm saw the coming-of-age for GPS and theater space operations in general. In 1993, the Fourteenth Air Force stood up at Vandenberg AFB, California with responsibility for all satellite operations within Air Force Space Command. In the fall of 1997, the Aerospace Operations Center (AOC) commenced operations with responsibility for the planning, tasking, and directing of all Air Force satellite activities.[136] In 1999, just prior to Operation Allied Force (OAF), Fourteenth Air Force began producing and disseminating a daily space tasking order (STO) which became the means for tasking all Air Force satellites, including GPS. During OAF, the Space AOC received theater requests for GPS and other space support, and tasked the space operations units to complete them.

By Operation Allied Force, GPS was fully operational and "did not merely assist in an unfolding strategy, but was thoroughly integrated into the air campaign right from the planning phase."[137] Unfortunately, because planners did not expect the war to last more than a couple of days, there was no strategy division in the combined air operations center (CAOC) until five weeks into the war.[138] Consequently, there were no specific objectives, tasks, measures of merit, or operational assessment until "late in the operation," according the AWOS report.[139] The report added, "There was no formal feedback mechanism to senior decision-makers to provide a daily assessment of progress

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[135] Lee Kennet, *The First Air War, 1914-1918* (New York: Simon and Schuster, 1991), 226.
[136] Fourteenth Air Force web site, available at http://www.vandenberg.af.mil/~associates/14af/14af_history/.
[137] Hasik and Ripp, 385.
[138] *Air War Over Serbia (AWOS) report, Aerospace Power in Operation Allied Force* (U), vol. 1, 305. (classified) Information extracted is unclassified.
[139] Ibid., 304.

toward objectives."[140] Despite the progress made in air and space integration, a deficient strategy-to-task methodology stymied operational assessment efforts.

Nevertheless, GPS contributed significantly in what turned out to be exclusively an air war. Much like in Desert Storm, GPS enabled allied aircraft to bomb around the clock, regardless of weather, and avoid having to manually guide weapons to their targets while flying in hostile airspace. These contributions are well documented.[141]

The almost unique political nature of the air war over Serbia however, levied strict constraints regarding collateral damage. The AWOS report claimed, "Not since Vietnam had the United States military confronted such political pressures to eliminate or minimize non-combatant casualties while attempting to achieve limited objectives."[142] Accordingly, one of the NATO military objectives was to "Attack Serbian air defenses with minimal collateral damage and civilian casualties."[143] GPS would have an important role in achieving this objective. In fact, it was during OAF that the GPS enhanced theater support (GETS) tactic was born.

The 2nd Space Operations Squadron (2 SOPS) in Colorado Springs, Colorado began experimenting with a concept to "optimize" the GPS constellation. Chapter 2 described GPS Enhanced Theater Support (GETS), a tactic that produces specific GPS effects in a given theater over a specified time. This concept, though not an approved tactic at the time, was experimented with during OAF.[144] Referred to during OAF as "optimizing the constellation", the tactic was experimented with on specific missions, primarily Tomahawk Land Attack Missile (TLAM) strikes. Satellite operators updated all GPS satellites scheduled to fly over the theater of operations during these selected strike "windows" with the most recent clock and ephemeris data.

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[140] Ibid., 306.
[141] Col John Larned, *Air War Over Serbia, Aerospace Power in Operation Allied Force,* "Air Force Space Forces," 30 June, 2000 (classified) Information extracted is unclassified; Hasik and Ripp.
[142] *Air War Over Serbia (AWOS) report, Aerospace Power in Operation Allied Force* (U), vol. 1, 49. (classified) Information extracted is unclassified.
[143] Ibid., 29.
[144] Air Force tactics must be formally vetted through the tactics development and approval process owned by Air Combat Command. These tactics are then documented in Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1 or Air Force Operational Tactics, Techniques, and Procedures (AFOTTP) 2-1. GPS "Optimization" was not a formal tactic during OAF. Based on successful experimentation during OAF, the concept was later formalized, tested, and approved by ACC for use prior to Operation Enduring Freedom.

The Space Warfare Center (SWC) conducted a study after OAF to determine the effects of the tactic. The study claimed, "By performing these additional updates, the information that each satellite in the constellation transmits to the user is 'fresher', and thus more accurate. This increased accuracy will theoretically translate to a more accurate GPS-based navigation solution for the warfighter."[145] As described in chapter 2, however, the actual benefit of the tactic is not an increase in the advertised accuracy of GPS in the theater, but an assurance of realizing the advertised accuracy.[146] In short, it reduces the chances of missing the target badly. The tactic is perfectly suited for use in a minimal collateral damage environment such as OAF.

The purpose of the SWC study was to describe the "effectiveness of the tactic on precision GPS munitions dropped during AWOS."[147] Several factors contribute to the accuracy of GPS-aided weapons, and distinguishing between those factors is complicated, if not impossible. Errors include clock and ephemeris data errors on the individual GPS satellites, GPS receiver errors, atmospheric errors (caused during the transmission of the signal from the satellite to the receiver), target location errors, and weapon guidance system errors. Any or all of these may contribute to the actual miss distance. However, the only error that the GPS system itself is responsible for is the satellite clock and ephemeris error, which is precisely what the optimization tactic reduces. The others error sources were not considered in the study, which assumed that the other errors were constant for each of the cases studied.[148] For example, given two Tomahawk missile strikes, only one supported by the tactic, the study compared the miss distances from the intended impact point to determine the effect of the tactic. In order to isolate the satellite clock and ephemeris data error, this methodology assumes that the atmospheric error, for example, was the same in both cases. While this was probably not the case, the study assumes that given a large enough sample size, the average error in all cases would be roughly the same. In chapter 2 I discussed the issue of distinguishing between multiple indirect effects. Distinguishing between indirect effects (sources of

[145] Lt Col Suzanne M. Beers, *Air War Over Serbia (AWOS) report, Aerospace Power in Operation Allied Force,* vol.2, sect. II, focus area 2, "Effect of Global Positioning System (GPS) Constellation Optimization" (U), 18 April 2000, 3. (classified) Information extracted is unclassified.
[146] AFTTP 3-1.28, *Space Operations*, 2002, section 4.7.4.2.
[147] Lt Col Suzanne Beers, 3.
[148] Lt Col Suzanne Beers.

error here) is simply not feasible and is a common problem with assessing space, as also discussed in detail in chapter 2.

By simply addressing miss distances of munitions, one is merely conducting a munitions effectiveness assessment (MEA). Therefore, in order to give the assessment more "operational meaning," the study transformed miss distances into a single shot probability of destruction (SSPD) using a model that correlated miss distances to a probability of destructing the target, based on the type and construction of each target.[149] In doing so, the study essentially evaluated the effect of the tactic on bomb damage assessment (BDA).[150] Unfortunately, the study stopped short of an operational assessment. It is true that operational objectives were hard to come by during OAF, yet the NATO military objective to "attack Serbian air defenses with minimal collateral damage and civilian casualties" provided the necessary criteria to do an operational assessment.[151] By combining the SSPD value for each strike with collateral damage information, the study could have been an extremely useful tool for showing the commander how well the optimization was helping him achieve his objective. In its defense, the SWC may not have had that data available and may not have been in the best position to do the study. However, *someone* needed to do it.

Finally, there were unintended effects associated with employing the tactic. Implementing the tactic requires the expenditure of additional resources--limited resources--that nominal GPS operations do not require. The report recognized a modest increase in manpower and in satellites contacts, which require the use of the Air Force Satellite Control Network (AFSCN). The increase in AFSCN usage during OAF was determined to be less than 5 percent, but the optimization was infrequent during OAF, as it was only an experiment. Increased usage of the tactic would obviously result in an increase in the resources required. Furthermore, heavy use of the tactic could require delaying preventive maintenance operations on equipment, which could have additional unintended consequences.

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[149] Ibid..

[150] A thorough description of the SSPD methodology can be found in Appendix A of the following report: "Assessment of Current and Near-Term Theater Needs for GPS Services" Version 6.1, GPS Support Center, 29 April 2005. (Report is classified, Appendix A is unclassified)

[151] *Air War Over Serbia (AWOS) report, Aerospace Power in Operation Allied Force* (U), vol. 1, 29. (classified) Information extracted is unclassified.

Although the driver for using the tactic was to reduce collateral damage during OAF, the report stopped short of relating the effect of the tactic to that objective.[152] Its findings, however, were noteworthy. It found that optimizing the constellation had a "statistically significant" effect on accuracy, suggesting it was not *operationally* significant.[153] The report concluded, "Future utilization of the tactic should be considered as a function of the magnitude of other GPS error sources, 2 SOPS operations tempo, and the operational value of the increased tactic."[154] The report was released on 30 June 2000.

Recall the analysis presented in the last chapter regarding effectiveness versus efficiency. The producer of the tactic is the space community, and the consumers of the tactic are the people dropping the bombs. It follows that the space community's perspective on effectiveness would consider the resources expended to implement it. Not surprisingly, the SWC's report addressed that concern. To the SWC's credit, the report appeared to provide an unbiased assessment of the effectiveness of optimizing GPS during OAF. The assessment of the tactic as "statistically significant", though perhaps not operationally relevant, left open the need to pursue the concept, yet resisted the temptation to make the space community appear to have contributed more than they actually did.

Following OAF, "GPS optimization" was approved as a formal tactic and used more extensively during OEF as GPS Enhanced Theater Support (GETS). Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1, Volume 28 (Space Operations), cautions that the tactic is "manpower intensive" and recommends, "This TTP should be used only for high-value strikes involving GPS-aided munitions. This TTP should not be used for routine flying operations or short flight time, GPS-aided munitions since the standard of GPS signal accuracy is maintained at a high degree every day."[155]

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[152] The only indication that the tactic was specifically used for the purpose of reducing collateral damage appears in an e-mail interview by this author with Lt Col Suzanne Beers, author of the report entitled "Air War Over Serbia, Aerospace Power in Operation Allied Force, Effects of Global Positioning System (GPS) Constellation Optimization", 18 April, 2000. E-mail dated 6 June 2005.
[153] Lt Col Suzanne Beers, 9.
[154] Col John Larned, 3.
[155] AFTTP 3-1.28, section 4.7.4.

GPS Assessment in Operation Enduring Freedom

By 2001, space operations were becoming normalized and well integrated with air operations. Fourteenth Air Force stood up a Strategy Division in their AOC. With virtually every theater of operations around the globe requesting space support, US Space Command (now US Strategic Command) adjudicated competing requests. The Strategy Division at Fourteenth Air Force ensured that space operations were planned and executed in accordance with US Space Command priorities. In addition, the Strategy Division worked side-by-side with the Strategy Divisions in various theaters to ensure they got the support they needed. Following the events of 9/11, the Strategy Division performed a very critical function as space support was in high demand among military and national organizations both at home and abroad. However, given the short amount time permitted to plan the OEF campaign, and the immaturity of the Strategy Division, once again space support assets were not tasked using a strategy-to-task methodology.

The highest support priority, of course, belonged to Operation Enduring Freedom. Among the many requests, the Combined Air Operations Center (CAOC) requested GETS support for several hours a day during the first several weeks of Operation Enduring Freedom. This request was honored even though the AWOS report on GPS optimization, which had been out for several months, recommended that use of the tactic be considered in light of its operational value and the increased operations tempo it required. All told, the 2nd Space Operations Squadron supported over 100 requests for GETS during OEF and increased manning in order to do so.[156]

Two studies specifically addressed the impact of GPS operations during OEF, one from Air Force Space Command (AFSPC) and one from Air Combat Command (ACC). The AFSPC study considered 1,805 Joint Direct Attack Munitions (JDAM) strikes during OEF. Like the SWC study from OAF, it specifically looked at the error from the signal in space (disregarding errors associated with targeting) and similarly correlated miss

[156] *Survey of Space Weapons System Employment by the 50th Space Wing in Support of Operation Iraqi Freedom*, 50 OSS/OSK, 8 October 2003, 33.

distances to probability of a "kill." The study also compared GETS-supported strikes with non-GETS-supported strikes to determine the impact of GETS. The study concluded that using GETS to kill all 1,805 targets would have resulted in a savings of munitions by four tenths of one percent.[157] This small benefit should have been considered in light of the cost of implementing the tactic (which appeared to be much more significant), but that issue was never addressed specifically. The Air Combat Command study examined munitions effectiveness during OEF and included a section on the use of GPS and its impact on munitions effectiveness, but did not compare GETS with non-GETS supported strikes.

In the end, although air and space operations were well coordinated and integrated, GETS was never assessed for effectiveness against specific objectives. The increased number of taskings from the theater, coupled with a lack of any evidence suggesting that GETS was not effective, resulted in an overall perception that GETS was vital to the air campaign in OEF. Relating this back to the analysis in chapter 1 regarding theories, prior to and during OEF, some supported the theory that the use of GETS would effectively assist commanders in achieving the goals of the air campaign. Without any evidence to the contrary, the apparent success of the air strikes in Afghanistan inductively supported that theory. As a result, the popularity of the GETS tactic carried over into Operation Iraqi Freedom, in spite of an increased operations tempo and increased risk of failure for GPS ground equipment and satellites.

[157] Briefing, Performance Analysis Working Group, Headquarters Air Force Space Command (HQ AFSPC)/XPY, subject: Impact of GPS Support During Operation Enduring Freedom, 15 Jan 2004.

GPS Assessment in Operation Iraqi Freedom

Col Larry James, the senior space officer in the CAOC during Operation Iraqi Freedom, stated, "We talked about Desert Storm being the first 'space war' but I'd call this the first *real* space war—where we have truly integrated 'space' throughout the battlespace, in ways we've never been able to do before."[158] Space support was more prominent and better integrated. The Strategy Division of the Space AOC was in lock step with the Strategy Division in the theater CAOC. Although a formal strategy-to-task methodology would not begin until July of 2004, rudimentary elements of the process were in place at the beginning of OIF.[159] Part of the commander's intent for GPS support during OIF was to increase signal accuracy and reduce the maximum error in the Iraqi theater.[160] Allied forces expended 8,646 GPS munition during the first 30 days of OIF.[161] Because of the continual bombing campaign in Iraq, and concerns over collateral damage in Baghdad, the CAOC requested 24-hour GETS support. Because of improvements in GETS implementation procedures, 2 SOPS provided continuous GETS support for the entire 30 days of the campaign.

Shortly after the president declared an end to major combat in OIF, the 50th Operations Group, which is responsible for the majority of Air Force satellite operations including GPS, developed a survey of space operations during OIF. "The purpose of this survey," the report states, "is to examine the battlespace effects" of space during OIF.[162] The survey is a very comprehensive assessment of space operations in OIF; unfortunately, it may have achieved its purpose of examining *effects*, but it did not examine *effectiveness*. The report makes no mention of the objectives that the various space operations were supporting. As has been stated, without objectives to assess against, one is limited to assessing effects. In defense of the survey, however, it was extremely thorough and identified some critical operational impacts.

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[158] Survey of Space Weapons System Employment.
[159] Lt Col Kevin Rhoades, Fourteenth Air Force chief of strategy, interview by author, 30 May 2005.
[160] "Assessment of Current and Near-Term Theater Needs for GPS Services" Version 6.1, GPS Support Center, 29 April 2005. (classified) Information extracted is unclassified.
[161] Survey of Space Weapons System Employment, 29.
[162] Survey of Space Weapons System Employment, 4.

The survey examined only the first 30 days of OIF since that was when the major portion of the air campaign occurred. Since 2 SOPS employed GETS continuously throughout the 30 day period, the survey did not compare GETS supported strikes with non-GETS supported strikes. Instead, it looked at the overall accuracy of GPS (with GETS). The survey claimed a 29 percent increase in the accuracy of the GPS signal received in Baghdad (compared to the average signal accuracy elsewhere) and similar increases throughout the area of operations.[163] The advertised accuracy in Baghdad during OIF was 2.73 meters, compared to 24.3-meter accuracy in Desert Storm.[164] This was also well within the 10 meter requirement in the targeting manual.[165] The space power survey focused strictly on the signal accuracy, a *direct* effect of the GETS support, while the studies from OAF and OEF measured miss distances and correlated them to probability of kill, which are second and third order *indirect* effects. While there is more certainty in measuring the direct effect, there is little understanding of the operational impact. However, the survey identified some important operational impacts of GETS.

First, the survey recognized that the signal had become so accurate that it was no longer the greatest source of error affecting a bomb's impact point. In Desert Storm, GPS had been the primary source of error. With GETS employed in OIF, the primary source of error was now target location.[166] It is important to point out here that there were more GPS satellites on orbit than in previous operations, including OEF. This alone is a significant contributing factor to signal accuracy. Nevertheless, the combination of additional satellites on orbit, the employment of GETS, and potentially other factors resulted in a signal accuracy that became almost irrelevant, at least from a bombing accuracy perspective. The report stated, "In Iraq, Regional GETS made accuracy so reliable it ceased to be a targeting consideration."[167]

Second, the survey determined that implementing GETS caused the number of GPS satellites contacts to increase by 20 percent (due to the additional uploads). Because of this increase, many routine GPS satellite contacts had to be passed along to the 1st Space Operations Squadron (1 SOPS). During that period, 1 SOPS surged to conduct 415

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[163] Survey of Space Weapons System Employment, 34.
[164] Ibid., 33.
[165] The 10 meter accuracy standard is directed by the Joint Munitions Effectiveness Manual (JMEM).
[166] Survey of Space Weapons System Employment, 33.
[167] Ibid., 37.

routine satellite contacts, thus enabling 2 SOPS to perform the critical uploads for GETS. While part of 1 SOPS function is to provide back-up capability to 2 SOPS, it also provides the same capabilities to several other space operations squadrons. Therefore, 415 additional contacts are significant. More importantly, the additional satellite contacts forced preventive maintenance work on both satellites and ground equipment to be deferred, increasing the risk of failures. Furthermore, GPS contacts are normally not a high priority on the Air Force Satellite Control Network (AFSCN). In order to get the additional GETS contacts scheduled they were given a higher priority, conceivably "bumping" other high priority missions to other times.[168] An operational assessment requires trading off the potentially high costs of implementing GETS with the apparently low payoff of GPS signal accuracy. Certainly these problems can be alleviated by purchasing additional ground equipment, launching more satellites, and boosting manpower. The question is whether GETS is worth the increased costs that such efforts would require. The space power survey poses the question, "Does GETS matter?" It answers the question by reiterating the statistical significance of the increased signal accuracy. Ultimately, however, the reports stated that in OIF, "GETS does not 'matter' because GPS' day-to-day, non-GETS accuracy fully meets—and exceeds—warfighting requirements."[169]

Finally, the report claimed, "The most important contribution of GETS is the reduction of signal error 'spiking'."[170] The report identified a 30 percent reduction in worst-case error spikes, thus reducing the chance of large signal errors. The "net effect" of GETS, the report concluded, was "a sweeping maximization on in-theater warfighting commanders' targeting options, together with minimized risk of collateral damage."[171] If there is no useful payoff in the increased accuracy of GETS, then the real benefit of GETS might be the reduction in collateral damage. So far, none of the studies conducted on GETS have attempted to quantify the impact on collateral damage. If there are specific objectives limiting collateral damage, such as existed in Kosovo, such studies are necessary to assess whether GETS is worth the increased operations tempo and risk of

[168] Ibid.
[169] Ibid, 38.
[170] Ibid.
[171] Ibid, 33.

failure to equipment. The OIF report suggests it may be more important in the future, as new technologies produce new weapons. It states, "Entirely new categories of weapons will become 'doctrinally employable' but are too risky today due to collateral damage concerns."[172] Perhaps by reducing collateral damage using GETS, these new weapon systems will become feasible.

This brings up one final point; this paper has purposely focused solely on GPS and its application in bombing accuracy. However, one cannot simply disregard the other uses of GPS. There were many other uses for GPS in theater besides precision weapon guidance—navigation, mine marking and avoidance, blue force tracking, etc. Some of these applications may benefit from the increased accuracy that GETS affords. Any assessment of the overall effectiveness of GETS, or GPS in general, must consider all the applications that use it and assess it against each of the individual objectives that GPS supports.

This thesis is not intended in any way to quantify the results of GETS support in previous conflicts or to assess whether or not GETS is worth the benefit to users in theater. The purpose is rather to point that GETS is not a "free utility". The cost of implementing the tactic must be considered along with the benefit. Furthermore, the benefit must measured against the specific objectives it supports. An operational assessment of GETS should answer the question: Are the effects produced commensurate with the expended resources and associated risks? The answer to the question may be different for different users and applications, but the final decision whether to continue GETS support should consider all users.

Many of the problems identified with GETS in this chapter are inherent in other types of space operations. This analysis used GPS and GETS as a case study to show a single example of how space assessment is problematic. Similar issues exist with tasking and assessing reconnaissance, communications, and missile warning operations. None of the campaigns discussed in this chapter had clear operational objectives for space operations from which tactical objectives and tactical tasks flow, leading one to *assume* the tasks are necessary. Furthermore, without the ability to assess those tasks against their objectives, the Air Force was predisposed to assess what they could—what usually

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[172] Ibid, 39.

amounted to munitions effectiveness or BDA. They have helped to assess whether we did things correctly. Operational assessments require much more analysis to determine effectiveness, but the payoff is the benefit of knowing whether the correct procedures were followed.

The concluding chapter will sort through all of the observations and issues associated with assessing space and recommend a path to success. It will assess which things we can fix, which things we cannot, and offer some advice for dealing with those things we may never be able to assess.

Conclusion

Summarizing the Space Assessment Problem

Operational assessment is the process of relating tactical tasks or "causes" to operational effects. In the military, tactical tasks are developed with the "theory" that they will enable victory on the battlefield. Using a strategy-to-task methodology, tasks are directly linked to battlefield effects. In the scientific realm, one might develop a theory that links a cause to an effect. The scientist tests the theory to see if it holds true. If there a finite number of possible test cases, he may be able to validate or prove the theory. However, when there are an infinite or indefinite number of cases to be tested, conclusive proof the theory may never happen. In either case, one can disprove the theory if it fails any single test case (at least disprove it for the variables with which it was tested). A better approach when there are an unmanageable number of test cases is to actively attempt to disprove the theory by falsification. This method seeks out those specific test cases under which the theory might fail.

Military operations are good candidates for this method for two reasons. First, there are usually an infinite or unmanageable number of tests required to prove the theory. Secondly, even if the set of test cases was manageable, war is often the only opportunity to test the theory under realistic conditions. Therefore, using assessment data collected during battle to try to invalidate our theories about how best to employ weapons can help commanders more effectively employ their forces. This is the very purpose of operational assessment. It informs theater commanders whether their tasks (causes) are producing the desired operational effects. In other words, it helps him understand not just if he is doing things right, but whether he is doing the right things.

Theater commanders typically leave the problem of assessing space to the space community because the theater has little knowledge of space operations and what they provide. This can lead to biased assessments when the producer is assessing his own effects. As a notable political scientist advised, "…you must be objective, in the sense of being willing to test your ideas and accept the results of fair tests, even if the negate your

preferences."[173] Similarly, the space community must willing to admit when particular space operations are either not as effective as hoped for, or that they just don't have sufficient evidence one way or the other. Instead, the space community often has an affinity simply to assess the tactical accomplishments, such as numbers of satellite contacts or amount of bandwidth provided, or number of GETS support requests completed. These tactical accomplishments can mask ineffectiveness at the operational level. It might show the theater commander that they are doing things right, but they do not tell him if they are doing the right things.

The propensity to dwell in the tactical assessment realm is not new for the Air Force. Phillip Meilinger's account of the difficulty assessing air power describes precisely the problem the Air Force is having today with space assessment. He writes,

> …after World War II—and some would say even today—airmen did not yet have the analytical cognitive, or intelligence tools necessary to determine the effects or the effectiveness of their strategic air operations. As a consequence, airmen began to do what they *could* do: they began solving the hundreds of tactical and technical problems that constantly cropped up, hoping that by doing things efficiently and competently they would also be doing them effectively. As a tool to achieve this hoped-for effectiveness they took to counting things, mistaking that practice for evaluation and measurement.[174]

Chapter 3 described similar situations when the Air Force assessed their strategic bombing in World War II and close air support in Korea and Vietnam. The similarities between these assessments of both air and space are astonishing.

The main reason that both air and space concentrated so much on tactical assessment is simply that it is inherently difficult to assess at the operational level. Operational level space effects are indirect, non-kinetic, indistinguishable from other effects, and often take time to recognize. Yet air power appeared to be just as much of a challenge for many of the same reasons, especially when compared to the seemingly simply task of operationally assessing land operations. David MacIsaac wrote, "'air power,' the

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[173] Alan S. Zuckerman, *Doing Political Science: An Introduction to Political Analysis* (San Francisco, CA: Westview Press, 1991), 2.
[174] Phillip Meilinger, "A History of Effects-Based Air Operations," *RAF Air Power Review*, Autumn 2003, 18., 2.

twentieth century's particular contribution to warfare, continues to defy our attempts at analysis."[175] Space power, one can easily argue, is the twenty-first century's contribution to warfare, and appears destined to challenge us as well. Meilinger believes that today there are more capable analytical tools available for assessment, "but we still lack a comprehensive and clear methodology for applying them."[176] The Air Force is now taking steps to develop that methodology.[177] Finally, one cannot overlook the simple fact that space operations are new to warfare and there just is not enough experience from which to learn. Yet, although space power lags air power by fifty years, the Air Force can narrow that gap by applying what we have learned about assessing air operations to the assessment problem.

Assessing Space is Essential

The case was made earlier that theater commander needs tactical assessments to know that he is doing things right, and operational assessments to know if he is doing the right things. He will probably know if he is not succeeding and want to know why. But what if he is succeeding? Does he assume he is doing the right things? Lt Gen Mike Short, the Combined Forces Air Component Commander (CFACC) during Operation Allied Force, suggests that the commander must determine if his success "was by design or by happenstance."[178] An assumption that it was by design, without any supporting evidence, can set a commander up for future failure.

Less obvious, but equally important, he needs to know if he is doing something that is *not* value added, particularly if it requires a limited resource. Since some space operations, such as general GPS support, are considered "free utilities" the theater

[175] David MacIsaac, "Voices from the Central Blue: The Air Power Theorists," in *Makers of Modern Strategy: from Machiavelli to the Nuclear Age*, ed. Peter Paret (Princeton, N.J.: Princeton University Press, 1986), 625.
[176] Phillip Meilinger, "A History of Effects-Based Air Operations," *RAF Air Power Review*, Autumn 2003, 2.
[177] Following OIF, General Jumper commissioned the Air Force Assessment Task Force. The team's charter is to streamline the overall assessment process and develop a new assessment methodology that focuses on operational level assessment rather BDA.
[178] Lt Gen Mike Short, remarks to students at: School of Advanced Air and Space Studies Warrior Application Course, Hurlburt Field, FL. 8 April 2005.

commander might be inclined to take everything he can get, with no evidence that is effectively enabling his objectives. However, other space applications are not necessarily "free." Space operations tailored for a particular theater, such as GETS, may obviate similar support in another theater. This may not be much of an issue with GETS since, at least in the current geopolitical climate; it is unlikely that GETS would be required in two theaters at the same time. However, GETS is only one example of space operations. It is not only possible, but frequent, that communications bandwidth to one theater comes at the expense of another. In addition, there are other costs. As discussed with GETS, there are costs associated with increased operations tempo, increased wear on ground equipment and satellites, and deferment of scheduled maintenance. In such cases, it is imperative to ensure that the space effects provided are in fact worth the cost. The space community, as the producer of the limited resource, is generally the one that needs to ensure its effective use.

Unfortunately, the unique qualities of space effects often require complex analyses to understand their impact on the battlefield. This prevents real-time operational assessment of space operations in most cases. For this reason, post-war analysis becomes critical. Some space operations may only be used in wartime, hence, that is the only opportunity to assess them. Therefore, effective use of space in the future depends upon a critical post-war assessment. Since post-war space assessments are only helpful in executing the next war, the theater commander may not go out of is way to request such an analysis. Once again, the space community must ensure it is accomplished.

Showing Signs of Progress

The Air Force, in general, has done a better job at operationally assessing space than meets the eye. What is often reported are the tactical and technical assessments that can appear as little more than a bean counting activity for the purpose of advertising how much space is contributing to the war effort. However, at a closer glance, there is sufficient evidence that both the space community and the rest of the Air Force are

beginning to ask the right questions and dig deeper to understand the real impact of space operations on the battlefield.

For example, in 2002 the 2 SOPS commander asked the GPS Operations Center (GPSOC) for an accurate assessment of current theater (Afghanistan) GPS needs citing that the continuing theater operations drove high GPS operations tempo and deferred satellite and ground system maintenance. In addition, he did not have any feedback on how well, or poorly, GPS was supporting theater operations.[179] As a result of that request, the GPSOC conducted an intensive study on the operational impacts of GPS. The results of the study have shown that the community is both asking the right questions and developing a sound methodology to operationally assess GPS support to theater operations. The report identified a four step process to assess the impact of space.

Four Step Process for Assessing the Impact of GPS on Theater Operations:

1) Conduct a survey of all theater missions that depend on GPS
2) Identify current theater missions that depend most heavily depend on GPS, using an effects-based analysis.
3) Analyze sensitivity of those missions to GPS performance.
4) Establish linkage between GPS operations and theater support requirements

One of the recommendations that came out of the report was to look at new potential options for assessing and responding to theater needs.[180] Following OEF, the Strategy Plans Team Chief in the CAOC, having read the report, requested an update to the report to include probability of kill computations as well as updates for new munitions. The updated report proposed an analysis that used both Single Shot Probability of Destruction (SSPD) and Maximum Radial Miss Distance (MRMD) as Measures of Effectiveness (MoE). Although the actual results of the report are classified and cannot be included here, the actual results of the study are not the point. The point is that not only are they developing the right measures of effectiveness to conduct operational assessments of

[179] "Assessment of Current and Near-Term Theater Needs for GPS Services" Version 6.1, GPS Support Center, 29 April 2005.
[180] Ibid.

GPS, they are also working closely with the theater to ensure that they are effectively providing the effects the theater needs.

Another improvement is in the tasking process. One of the recurring problems identified in this report was that space support taskings were not developed using a strategy-to-task methodology. As a result, space tasks did not directly support higher level objectives to assess them against. However, beginning in July 2004, Fourteenth Air Force began using strategy-to-task methods in earnest.[181] For global space taskings, Fourteenth Air Force developed operational objectives, tactical objectives, and tactical tasks, complete with measures of effectiveness, to support the operational objective. For tasks that support theater commanders specifically, the theater commander may develop his own operational objective and Fourteenth Air Force develops tactical objectives and tasks to support his objective. This process ensures that all the objectives are lined up for doing the assessments. In general, all the tactical objectives support a single operational objective to "Gain and Maintain Space Superiority," although the theater commander may develop his own.[182] The standard GPS objectives and tasks used at Fourteenth Air Force are shown below with the associated measures of effectiveness.[183]

Operational Objective: Gain and maintain space superiority in order to ensure friendly access to space and prevent adversary access to the same.

Success Indicator: U.S. and coalition forces have uninhibited access to space, and adversary's access to space is restricted.

Tactical Objective: Deliver tailored space effects and products to U.S. and coalition forces.

Measure of Effectiveness: U.S. and coalition forces receive timely and accurate space effects and products.

Tactical Task: Provide optimized GPS support over the Joint Operating Area.

Measure of Performance: GPS signal in space does not exceed 6 meters.

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181 Lt Col Kevin Rhoades, Fourteenth Air Force chief of strategy, interview by author, 30 May 2005.
182 Ibid.
183 Fourteenth Air Force SIPRNET web site, available at http://www.vandenberg.af.smil.mil. (classified) Information extracted is unclassified.

Both Fourteenth Air Force and the theater must work together to do the assessment. The "owner" of the operational objective is ultimately responsible for the final operational assessment. Fourteenth Air Force will always conduct the tactical assessment and will provide it to the theater commander if he is responsible for the operational assessment. Additionally, Fourteenth Air Force will have a billet for a full-time assessor beginning the fall of 2005. The next section will discuss a few areas to improve on, but clearly the space community has their arms around the problem and is working with the theater to ensure they are providing the effects the theater needs.

Areas for Improvement

The operational objective developed by Fourteenth Air Force is to "Gain and maintain space superiority in order to ensure friendly access to space and prevent adversary access to the same."[184] Using the strategy-to-task process, all of the tactical objectives support this operational objective. However, the tactical objective for GPS is to provide optimized GPS support over the Joint Operating Area. The disconnect is that providing optimized GPS support does not serve the purpose of gaining or maintaining space superiority. Rather, gaining space superiority permits the optimization of GPS. If the linkage between the tasks and the objectives is not present, the purpose of the entire methodology is defeated and it seriously complicates assessment since achieving the tactical task or objective does not assist in achieving the operational objective.

Additionally, the measure of effectiveness above is not actually measurable and would be difficult to determine when it has occurred. Fourteenth Air Force is aware of these issues and admittedly is still trying to iron out the wrinkles in the process. The bottom line, however, is that they have engaged the problem, they have a process, and they are working with the theater to assess their activities.

A final area may be already improving. During both OEF and OIF, both the theater and the space community appeared to have ignored the studies conducted after OAF on GETS. The study clearly indicated little operational utility of the GPS optimization tactic

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[184] Ibid.

and recommended, “Future utilization of the tactic should be considered as a function of the magnitude of other GPS error sources, 2 SOPS operations tempo, and the operational value of the increased tactic.”[185] The evidence suggests that no such utilization study occurred before either OEF or OIF. The space community needs to “push back” when theater requests for space support are not sensible.

The Air Force should take note of these areas for improvement, but overall the space community and theater together have shown that they are beginning to understand the problems and are taking step to improve the space assessment process.

Assessment: An Art and Science

The scientific method serves the assessment community well by strengthening theories relating cause and effect. Carl von Clausewitz stressed that cause and effect relationships must be critically analyzed to narrow the gap in a theory. However, Clausewitz is very clear that there will always be a gap in the theory, something that cannot be proven or completely explained. In developing a theory, “judgment has to be suspended.”[186] Yet, for the practitioner, the art of war demands he use judgment. Therefore, while the theorists must suspend judgment in developing the theory, the theory itself should serve as “aids to judgment” for the practitioner.[187] Assessment is the art of applying scientifically developed theories.

Lt Gen Mike Short stated that just because a commander succeeds, he should not assume he is doing the right things and vice versa. He says that assessment requires professional judgment and courage to stay the course when necessary and no abandon the plan too soon if there are no immediate results. As a commander, one “must accept that you will make major decisions without

[185] Col John Larned, *Air War Over Serbia, Aerospace Power in Operation Allied Force,* “Air Force Space Forces,” 30 June, 2000, 86. (classified) Information extracted is unclassified
[186] Clausewitz, 156.
[187] Ibid, 158.

perfect information--you must believe in what you are doing but not close your mind to the possibility that you may be wrong."[188] General Short adds, "In the end, assessment is more art than science--at some point the commander must decide success or failure, stay the course or switch gears, did we make the enemy change his behavior or were we just lucky?"[189]

Conclusion

This thesis has argued that operational assessment of space operations is difficult, yet critical to the development of space power. Since Desert Storm, space has played an increasing role in military operations will continue to do so in the future. However, the Air Force has not generally done a good job of assessing space at the operational level. In addition to the difficulties inherent in assessing space effects, rarely are space tasks linked to operational objectives, which is necessary to do an operational assessment. As a result, the space community has settled for tactical assessment data, which is more readily available, but less useful to military commanders. Like the man in the introduction, searching for his keys, the focus has been on where the light is bright, but far from where the object rests.

Although the thesis specifically used GPS and the GETS tactic to demonstrate the assessment problems with space, these problems are by no means limited to GPS. Nearly all space operations experience the same difficulties to some extent. The experiences assessing strategic bombing and close air support in the past have shown that the Air Force has struggled with these issues before. Through these experiences, it is clear that operational assessment is much more an art than a science. It is also apparent that the Air Force did not apply lessons learned from air power to the space assessment problem. Recently, however, the Air Force has begun to recognize the importance of operational

[188] Short interview.
[189] Clausewitz, 156.

assessment and shown signs of improving the process for assessing space. In doing so, the Air Force is working closely with the theater to understand the desired and actual impact of space activities on theater operations, versus the assumed impact. Continuing in this manner will enable the Air Force to tailor space support to take advantage of the beneficial activities without wasting limited resources on those activities that do not add value.

Hal Winton, professor at the Air Force's School of Advanced Air and Space Studies, wrote of air power in 1992:

> The categories of air power vary widely from one to analyst to another. The explanations of cause and effect relationships are largely unexplored. The connections between air power and warfare in other media have similarly not received systematic treatment. And, with such a perilously thin theoretical base, the ability to anticipate future trends remains hostage to hype concerning the latest technological developments, with little consideration given to the tendencies that may counteract these advances.[190]

This statement is just as true for space today as it was for air then. Operational assessments of space will help explain those cause and effect relationships and begin to populate the theoretical base necessary to understand how space can best be employed in future conflicts. Winton argues that after nearly 100 years of military aviation, someone has yet to write a comprehensive theory on air power, in part because of the difficulties in assessing it.[191] The ability to conduct operational assessment of space operations today will help the space community understand how best to employ it and support the development of early space power theories. The first step is to not simply search where the light is best.

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[190] Winton, Harold R. "A Black Hole in the Wild Blue Yonder: The Need for a Comprehensive Theory of Air Power." Air Power History 39, no. 4 (Winter 1992): 42.
[191] Ibid., 32.

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